NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

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This Association, as a Body, is not responsible for statements or opinions of any of its members.

FEBRUARY MEETING.

YOUNG'S HOTEL, BOSTON, Feb. 12, 1890.

An adjourned meeting of the Association was held on Wednesday, February 12, at Young's Hotel. President Brackett sat at the centre of the head table, and the following-named members were present: —

Solon M. Allis, Superintendent, Malden, Mass.
Geo. E. Batchelder, Registrar, Worcester, Mass.
Joseph E. Beals, Clerk and Registrar, Middleboro', Mass.
Dexter Brackett, Superintendent Eastern Division, Boston, Mass.
Geo. F. Chace, Superintendent, Taunton, Mass.
R. C. P. Coggeshall, Superintendent, New Bedford, Mass.
Byron I. Cook, Superintendent, Woonsocket, R.I.
F. H. Crandall, Superintendent, Burlington, Vt.
Lucas Cushing, Assistant Superintendent, Boston, Mass.
Edwin Darling, Superintendent, Pawtucket, R.I.
Thos. M. Drown, Professor Chemistry, Institute Technology, Boston, Mass.
Desmond FitzGerald, Superintendent Western Division, Brookline, Mass.
F. F. Forbes, Superintendent, Brookline, Mass.
Z. R. Forbes, Assistant Superintendent, Brookline, Mass.
Frank L. Fuller, Civil Engineer, Boston, Mass.
Albert S. Glover, West Newton, Mass.
J. A. Gould, Jr., Assistant Engineer, Boston, Mass.
John L. Harrington, Cambridge, Mass.
William M. Hawes, Water Commissioner, Fall River, Mass.
Horace G. Holden, Superintendent, Nashua, N.H.
John C. Haskell, Superintendent, Lynn, Mass.
Patrick Kieran, Superintendent, Fall River, Mass.
Wilbur F. Learned, Assistant Engineer, Boston, Mass.
Hiram Nevons, Superintendent, Cambridge, Mass.
Albert F. Noyes, City Engineer, West Newton, Mass.
F. H. Parker, Commissioner, Burlington, Vt.
Dwight Porter, Assistant Professor C. E., Institute Technology, Boston, Mass.
G. J. Ries, Superintendent, East Weymouth, Mass.

W. W. Robertson, Registrar, Fall River, Mass.
A. H. Salisbury, Superintendent, Lawrence, Mass.
Chas. W. S. Seymour, Superintendent, Hingham, Mass.
Solon F. Smith, Superintendent, Grafton, Mass.
Lucien A. Taylor, Civil Engineer and Contractor, Boston, Mass.
M. M. Tidd, Hydraulic Engineer, Boston, Mass.
Chas. K. Walker, Superintendent, Manchester, N.H.
W. H. Vaughn, Superintendent, Wellesley Hills, Mass.
Herbert F. Whittier, Registrar, Lawrence, Mass.
Horace B. Winship, Civil Engineer, Norwich, Conn.
Geo. E. Winslow, Superintendent, Waltham, Mass.
E. T. Wiswall, Water Commissioner, West Newton, Mass.
Millard F. Wright, Superintendent, Lowell, Mass.
Hon. E. R. Jones, Boston, Mass.
F. W. Shepherd, "Fire and Water," New York.
A. W. Worthley, American Frost Meter, Boston, Mass.
A. H. Brodrick, Chadwick Lead Works Co., Boston, Mass.
E. L. Ross, Chapman Valve Co., Indian Orchard, Mass.
F. H. Hayes, Dean Steam Pump Company, Holyoke, Mass.
W. D. Gorham (Gilchrist & Gorham), Boston, Mass.
W. H. Gallison, Pipe and Fittings, Boston, Mass.
H. D. Winton, Hersey Meter, South Boston, Mass.
J. A. Tilden, Hersey Meter, South Boston, Mass.
Henry F. Jenks, Fountains, Pawtucket, R.I.
Sumner & Goodwin, Pipe and Fittings, Boston, Mass.
John K. Otis, Union Water Meter, Worcester, Mass.
B. Frank Polsey, Walworth Manufacturing Company, Boston, Mass.
G. L. Whittemore, Geo. Woodman & Co., Boston, Mass.
J. M. Betton, H. R. Worthington Co., New York City.

GUESTS.

John M. Jordan, Water Commissioner, Malden, Mass.
Walter Clifford, Mayor, New Bedford, Mass.
Wm. T. Sedgwick, Professor, Massachusetts Institute Technology, Boston, Mass.
Mr. Hunnewell, Water Commissioner, Brookline, Mass.
Robert Grant, Chairman Water Board, Boston, Mass.
W. E. Webber, Water Board, Boston, Mass.
R. J. Flynn, Water Board, Boston, Mass.
E. S. Sullivan, Superintendent Mystic Division, Boston, Mass.
Mr. McCormick, Water Commissioner, Lawrence, Mass.
Bert J. Getchell, Clerk, New London, Conn.
F. B. Webster, Wellesley Hills, Mass.
E. LeBaron, Commissioner, Middleboro', Mass.
Ralph W. Cook.
A. F. Salmon, Mr. Holt, } Lowell Water Board.
S. A. Welch, Worcester, Mass.

After dinner had been served the meeting was called to order by the President, and the Secretary presented the following names of applicants for membership: —

RESIDENT ACTIVE MEMBERS.

P. F. Babbidge, Superintendent, Keene, N.H.

Robert Grant, Chairman Water Board, Boston.

E. P. LeBaron, Chairman Water Board, Middleboro'.

Wm. B. Littlefield, Water Commissioner, Lynn.

Wm. T. Sedgwick, Professor Biology, Mass. Institute Technology, Boston, Mass.

Eugene S. Sullivan, Superintendent Mystic Division, Boston.

NON-RESIDENT ACTIVE MEMBERS.

B. F. Steben, Manager Water Company, Brockville, Ontario, Canada.

HONORARY MEMBER.

F. W. Shepherd, Editor "Fire and Water," New York City.

On motion of Mr. Hawes, the Secretary was instructed to cast the ballot of the Association for the above-named gentlemen, which he did, and the President announced their election as members of the Association.

There being no other matter of business to come before the meeting, the President introduced Mr. F. F. Forbes, Superintendent of the Water Works at Brookline, who read a paper entitled "A Study of Algæ Growths in Reservoirs and Ponds."

QUARTERLY MEETING.

YOUNG'S HOTEL, BOSTON, March 12, 1890.

The following guests and members of the Association were present: —

Active Members: — Frank A. Andrews, Assistant Superintendent, Nashua, N.H.; Charles F. Allen, Treasurer, Hyde Park, Mass.; Solon M. Allis, Superintendent, Malden, Mass.; P. F. Babbidge, Superintendent, Nashua, N.H.; Geo. E. Batchelder, Registrar, Worcester, Mass.; John G. Brady, Commissioner, Worcester, Mass.; Joseph E. Beals, Clerk, Middleboro', Mass.; A. P. Barrett, Registrar, Woburn, Mass.; Dexter Brackett, Superintendent, Boston, Mass.; George F. Chace, Superintendent, Taunton, Mass.; F. H. Crandall, Superintendent, Burlington, Vt.; R. C. P. Coggeshall, Superintendent, New Bedford, Mass.; Byron I. Cook, Superintendent, Woonsocket, R.I.; Lucas Cushing, Assistant Superintendent, Boston, Mass.; Charles E. Chandler, City Engineer, Norwich, Conn.; P. F. Crilly, Superintendent, Woburn, Mass.; John W. Ellis, Water Commissioner, Woonsocket, R.I.; F. F. Forbes, Superintendent, Brookline, Mass.; E. E. Farnham, Superintendent, Sharon, Mass.; Melvin C. French, Superintendent, South Braintree, Mass.; Frank L. Fuller, Civil Engineer, Boston, Mass.; L. E. Forbes, Assistant Superintendent, Brookline, Mass.; Albert S. Glover, West Newton, Mass.; John A. Gould, Jr., Assistant Engineer, Boston, Mass.; E. A. W. Hammatt, Civil Engineer, Boston, Mass.; William F. Harbach, Water Commissioner, Newton Centre, Mass.; William

M. Hawes, Water Commissioner, Fall River, Mass.; Horace G. Holden, Superintendent, Nashua, N.H.; Horatio N. Hyde, Jr., Superintendent, Newtonville, Mass.; Patrick Kieran, Superintendent, Fall River, Mass.; E. P. LeBaron, Chairman Water Board, Middleboro', Mass.; W. F. Learned, Civil Engineer, Boston, Mass.; James W. Morse, Superintendent, Natick, Mass.; Hiram Nevons, Superintendent, Cambridge, Mass.; A. F. Noyes, City Engineer, West Newton, Mass.; Weaver Osborne, Commissioner, Fall River, Mass.; Daniel Russell, Everett, Mass.; George J. Ries, Superintendent, East Weymouth, Mass.; Walter H. Richards, Superintendent, New London, Conn.; L. Fred Rice, Civil Engineer, Boston, Mass.; George A. Stacy, Superintendent, Marlboro', Mass.; W. T. Sedgwick, Professor Biology, Massachusetts Institute Technology, Boston, Mass.; B. F. Steben, Manager, Brockville, Canada; A. H. Salisbury, Superintendent, Lawrence, Mass.; Chas. W. S. Seymour, Superintendent, Hingham, Mass.; Lucian A. Taylor, Civil Engineer, Boston, Mass.; Joseph G. Tenney, Superintendent, Leominster, Mass.; W. H. Vaughn, Superintendent, Wellesley Hills, Mass.; F. W. Whitlock, Civil Engineer, Waterbury, Conn.; Millard F. Wright, Superintendent, Lowell, Mass.; G. E. Winslow, Superintendent, Waltham, Mass.; E. T. Wiswall, Commissioner, West Newton, Mass.

Associate Members: — J. H. Coggeshall and C. H. Hobson, of H. R. Barker Manufacturing Co., Lowell, Mass.; James M. Betton, Boston, Mass.; E. G. Ross, of Chapman Valve Manufacturing Co., Indian Orchard, Mass.; J. A. Mitsch, of W. H. Gallison, Boston, Mass.; J. A. Tilden and W. B. Winton, Hersey Meter Co., South Boston, Mass.; Henry F. Jenks, Pawtucket, R.I.; John C. Kelley, National Meter Co., New York City; Walter B. Nye, Warren Filter, Boston, Mass.; F. E. Stevens, Peet Valve Co., Boston, Mass.; George Ross and E. C. Woodward, Troy, N.Y.; G. A. Polsey, Sumner & Goodwin, Boston, Mass.; W. H. Moulton, Union Water Meter Co., Worcester, Mass.; E. L. Abbott, Water Waste Prevention Co., New York; B. F. Polsey, Walworth Manufacturing Co., Boston, Mass.; G. L. Whittemore, Geo. Woodman & Co., Boston, Mass.; A. A. Blossom, Whittier Machine Co., South Boston, Mass.

Guests: — Mayor H. M. Burr, Newton, Mass.; A. S. Rich, Hingham, Mass.; James T. Murphy, Commissioner, Marlboro', Mass.; Frank Wall, Marlboro', Mass.; M. D. Dexter, Norwich, Conn.; Thomas Rogers, Nashua, N.H.; E. A. Stevens, Jr., Commissioner, Malden, Mass.; Edmund Brown, East Weymouth, Mass.; E. A. Corey, Boston, Mass.; W. L. Goddard, Boston, Mass.; W. B. Hawes, Fall River, Mass.; E. Severy, Waterbury, Conn.; W. F. Whittemore, Leicester, Mass.; M. N. Boardman, Worcester, Mass.

After dinner had been served, President Brackett called the company to order, and the Secretary presented the applications of the following-named persons for membership, they having been duly approved by the Executive Committee: —

Resident Active: — Walter Clifford, President Water Board, New Bedford, Mass.; F. Floyd Weld, City Engineer, Waterbury, Conn.; P. F. Crilly, Superintendent, Woburn, Mass.; A. P. Barrett, Registrar, Woburn, Mass.; A. E. Brown, Assistant Superintendent, Milford, Mass.

Non-Resident Active: — Reuben Shirreffs, 2d Assistant Engineer East Jersey Water Co., Paterson, N.J.; M. O'Connor, Superintendent, Bayonne, N.J.

Associate: — W. T. Montgomery, Agent Providence Steam & Gas Pipe Co.,

Boston; W. J. Ranton, Superintendent Porter Manufacturing Co., Syracuse, N.Y.; E. B. Williams, Steam, Gas, and Water Valve, Boston, Mass.

On motion of Mr. Hawes the Secretary was instructed to cast the ballot of the Association for the gentlemen named, which he did, and the President declared them to have been elected members.

The PRESIDENT. — The Secretary has one other matter from the Executive Committee to present.

The SECRETARY. — The Executive Committee has considered the matter of amending Art. 3 of our Constitution and By-Laws, which relates to initiation fees and dues, so that it shall read as follows: "Section 2. That the regular annual dues of members shall be as follows, payable in advance: For active members, $2; for associate members, $10." The Executive Committee recommend that that amendment be made.

Mr. NOYES. — Some of us do not have the By-Laws; will the Secretary be good enough to read the article as it now stands?

The PRESIDENT. — The article now provides "that the regular annual dues of members shall be as follows: For active members, $2; for associate members, $5." The change is from $5 to $10 for the annual dues of the associate members.

On motion of Mr. Hawes, the amendment was unanimously adopted.

The PRESIDENT. — I will take this opportunity to say that this will probably be the last meeting before the annual meeting, which will be held at Portland on the 11th, 12th, and 13th of June; and I hope all who are here will endeavor to attend that meeting. We certainly have had a very encouraging attendance at all the meetings this winter. I have been very much gratified by the large attendance which we have had at all of our meetings, and also by our gain in membership. The membership a year ago was 282. Since that time, including those who have been elected to-day, there have been 57 new members elected, making our membership at present 337, which I think is considerably in excess of the membership of the American Association.

Mr. HOLDEN. — Before adjournment I would like to call the attention of this meeting to the Convention of the American Water Works Association, which is to be held in Chicago, commencing May 20th, and lasting three days. This organization, as you are aware, is composed of representative men from all the principal water works throughout the country; and, although the programme of arrangements is not yet complete, I am confident this will be the largest and most successful as well as the most interesting gathering of water-works officials we have ever had. In behalf of the American Association I wish to extend an invitation to all the members of this Association to meet with them at Chicago.

The PRESIDENT. — I will take this opportunity to call your attention to the subject of the exchange of sketches, which it has been our custom to have at the annual meeting; and I do it this time in order that you may all have it in mind, because between now and the middle of June you will have plenty of time to prepare something. For fear that some may not understand exactly what this means, I will state that each member is desired to contribute from 50 to 100 copies of a sketch on some subject, the sketch either to be prepared by blueprint or any other well-known duplicating process, and to illustrate tools or devices, or anything which you think will be of interest to other members of the

Association. They are all to be prepared of a uniform size, 10 × 15 inches. I trust that a large number of sketches will be presented at the meeting in Portland.

On motion of Mr. Hawes, the President appointed Messrs. Whitney, of Newton, Robertson, of Fall River, and Batchelder, of Worcester, a committee to consider and report to the Association, at its annual meeting, upon "A Proper Basis for the Establishment of Water Rates."

The following-named papers were then read and discussed: "Method of Cleaning the Distributing Reservoir of the New Bedford Water Works," by R. C. P. Coggeshall, Superintendent, New Bedford, Mass.; "Experience with a Thirty-Inch Gate," by Hiram F. Nevons, Superintendent, Cambridge, Mass.; "Inequalities in Water Rates," by Horace G. Holden, Superintendent, Nashua, N.H.; "An Experience in Excavating in Quicksand," by Albert F. Noyes, City Engineer, Newton, Mass.; "Artesian Well Experiment at Taunton, Mass.," by George F. Chace, Superintendent, Taunton, Mass.

Adjourned.

NOTES ON LAYING A TWENTY-INCH MAIN.

A Paper read before the Association, January 8, 1890.

BY

WALTER H. RICHARDS, Supt. Water Works, New London, Conn.

Mr. RICHARDS. — Mr. President, at the Springfield meeting there was a committee appointed to report on the thickness of cast-iron pipe, and at the Providence meeting there was a committee appointed to report on special castings. I believe neither of these committees has ever reported, and it is mainly for the purpose of trying to bring about a discussion on these important subjects that I present the following notes on the laying of a 20-inch cast-iron pipe in New London.

The main in question was designed to increase the supply to the city of New London. It was 5 miles long, and laid generally parallel to a 16-inch cement-lined wrought-iron pipe, and at a distance of from 8 to 200 feet therefrom.

The pipe was divided into two classes; Class A was used for heads of from 20 to 50 feet, was 63-100th inches thick, and weighed 138 pounds to the foot. Class B, for heads of 50 to 160 feet, was 70-100th inches thick, and weighed 154 pounds to the foot. It was necessary to cart the pipe over very rough roads from 2 to 6 miles, and these thicknesses were decided upon with due consideration of the effects of transportation, but lighter than is generally used for work of this kind. The pipes were subjected to rigid inspection at the foundry, and of the total number cast 10 % were rejected. Of the total number accepted at the foundry about 7 % were broken in transportation or handling, or by blasting; a large majority of the breaks being checks running 2 or 3 inches from the spigot end. The percentage of cracked pipe was about the same for each class of pipe.

The bells were of a design similar to the Providence bell, being 3¾ inches deep, with ⅝-inch joint room, taking about 27 pounds of lead for each joint.

The pipe was laid on perfectly straight lines and nearly straight grades, all changes in direction being made with bends of 20 feet radius. Bends of three different lengths were used, and the angles in the line arranged to take one or a combination of two or more of these specials at each angle.

Before the pipe was covered it was tested by making a 2-inch connection with the old main, the open end of the pipe being stopped with a wooden plug bolted in. By this method any defect in caulking was discovered and remedied at once, and it is thought that many small-joint leaks that never would have shown above ground were thus prevented. It is believed that the little trouble and expense occasioned by the test were justified by a considerable saving in repairs, as but two small joint-leaks and two cracked pipes were found in the final test, one of the pipes being cracked by a cave in the bank during the filling of the trench.

The PRESIDENT. — If this paper will bring about any discussion on the question, as Mr. Richards suggests, of the thickness of pipe that is necessary, and also on the subject of designing special castings, as it certainly ought to, I think it will be of value to the Association. The paper is now open for discussion, and I should be very glad to hear from any members.

Mr. JONES. — The first 20-inch pipe laid in Boston, when they knew but little about them, to be sure, weighed about 200 pounds to the foot, and was nearly seven-eighths of an inch thick, — a little over three-quarters. If a mistake was made, it was made on the safe side. I can only speak in general terms about such things, but I think there are two things with regard to laying water-pipes that are open to criticism: one is that they do not make them thick enough, and the other that they do not make them large enough.

Mr. HAWES. — Mr. Richards stated that, with regard to the thickness of the pipe, they took into consideration the carting of it six miles. How thin or how thick would a pipe have to be to shake to pieces in carting six miles? (Laughter.)

Mr. RICHARDS. — That is the only consideration, really, that governed, because the pipe might be very much thinner and still stand the pressure; it is only to provide against transportation that you make them heavy.

Mr. JONES. — When the gentleman speaks about its being thick enough to stand the pressure, even if it were thinner than that, does he take into consideration the fact that the pipe is liable to decay, and does he take into consideration the question of water-hammer?

Mr. RICHARDS. — The pipe in question was for a supply main without any taps off of it, and the water-hammer on it would be comparatively small to what it would be in a distribution pipe in the city.

Mr. JONES. — I cannot agree with the gentleman there, because the first 30-inch main in Boston burst with the water-hammer from the fountain playing on the Common, and it was quite a serious break. Another break was on the top of the hill, from the water-hammer. The pressure then in Boston, I believe, was only about 50 pounds to the square inch.

Mr. FULLER. — I would like to ask Mr. Richards if he couldn't have got his curves with straight pipe, if he had sufficient radius, without using specially cast pipe.

Mr. RICHARDS. — Yes, they could have been made with straight pipe, but

the joint room, three-eighths of an inch, would have necessitated a very large radius.

Mr. DARLING. — You have the short bell, and you cannot make a curve in them; with a longer bell you could curve your pipe more.

The PRESIDENT. — I suppose there is no question but that the thickness of pipes in general use is larger than is necessary to withstand the static pressure; but the constant tendency at the present time is, I think, toward increase of pressure, on account of increased heights of buildings, and on account of the water-hammer, due to the increased use of water elevators. The pressure on the pipes is in many cases increased very much beyond what they originally were designed to withstand. In Boston we have large sections of the city where the pipes laid in 1848, when there was a pressure of perhaps 40 pounds, are to-day, by the substitution of high service, withstanding a pressure of from 90 to 100 pounds, to say nothing of the additional pressure due to the water-hammer. I think the increasing tendency in this direction must be considered by any one who is designing a system of water-supply.

Mr. DARLING. — I want to say just a word. I think the greatest mistake that is made by a great many towns and cities to-day is, that they try to economize too much in putting in not only light pipe, but in putting in small-sized pipe. As our President has remarked, there is a constant tendency toward an increased use of the water. In the first place, take the hydrant service. That is one of the greatest and most important features of any water works, to say nothing about the family use. Then when you come to take on this new feature, which the insurance companies have brought up by the introduction of the automatic sprinklers, you have got to provide for that in addition. Then, too, there are the elevators, and a general increase in the use of water for all purposes, and you must have large pipes to get such a service as you want. So I say that the greatest mistake to-day is, that cities and towns do not put in pipes large enough to provide for the growth there is sure to be in the years to come. They are too careful, too economical, too prudent. They should put in larger-sized pipes and pipes of good thickness. Now, when you speak of water-ram, you don't know what circumstances will produce it. There are to-day, with these new complications, ten chances that you will get a water-ram where there was not one years ago. With the elevators and sprinklers, you do not know what minute you are going to be called upon to furnish an excessive supply of water at some particular point, and that is controlled by the parties themselves; and they do not stop to think whether they should not take time enough in shutting off the water, but they are liable to shut it off immediately; and if they do shut it off immediately, you are going to get a water-ram; you cannot help it.

Mr. JONES. — One word more. Our President neglected or forgot to mention something with regard to the decay of water-pipes in Boston. Boston, to be sure, is on the seaboard; fortunately not all water-works are so situated; and a good many pipes here are laid in ground that has been filled in from the docks with dock mud. In ten years after the water works were laid here, 12-inch pipes, that were nearly five-eighths of an inch thick, were so damaged by this dock mud that you could cut them with a knife as you cut a lead-pencil; and they are taking them out every week now, I suppose, that you can cut in the same way. So, certainly, it is policy in Boston to use pipe large enough to resist,

for a reasonable time, such influences. It may be that is something which does not have to be taken account of in the country, but, nevertheless, if I was to lay pipes again, I should try to make a mistake in the direction of laying large pipes.

Mr. TIDD. — I believe, with the gentleman who has last spoken, that the thickness of pipe should be governed somewhat by where it is to be put. I have no doubt that in a soil such as he speaks of, a thicker pipe would be required than, perhaps, would be required in a different soil. But with the soils which we usually meet in building water works through the country, my impression is we have been using unnecessarily large pipe. My attention has been called to that particularly by reading the reports of tests at the Watertown Arsenal. The breaking strain of a 16-inch pipe, I think 44-100ths of an inch thick, was about 4,800 feet head. Now, it seems to me we might get along with one-half that, for probably the water-hammer never would come up to twenty-five per cent. of it. In the early stages of water-works construction it was customary to use very thick pipe, but I think the experience we have had lately will warrant us in using thinner pipe in many places. I have always believed in the principle of prevention of water-ram wherever possible. I don't believe that shutting off a 4-inch pipe with a valve should ever be allowed. I think that will break any pipe. It seems to me, as I have said before, we have been wasting a great deal of iron. I agree with the gentleman who has last spoken as to the size of the pipes. I never knew a pipe too large, but I have seen lots of them too small.

Mr. GOWAN. — I would like to ask if the quality of the iron may not have considerable to do with the question, and the manner in which it is cast; and if there is any way in which a man not familiar with pipe casting can tell whether or no he is getting a good pipe.

Mr. TIDD. — My remarks were based on the supposition that good iron is used. We generally specify that the iron shall not be less than 10,000 pounds tensile strain, and the pipe should be cast on end, bells out. Of course, if we are going to use pot-metal, the weight I suggest would not be sufficient. (Laughter.)

Mr. RICHARDS. — Of course I wouldn't advocate the use of a thin pipe, if you are not going to inspect it. If you are going to take any pipe the foundry will send you, I should advise you to have it as thick as they will make it.

Mr. TIDD. — A foot, at least.

Mr. RICHARDS. — This pipe we used was very carefully inspected, and was tested to 300 pounds pressure at the foundry, and hammered by my own inspector, and for that reason I think it is plenty strong enough.

The PRESIDENT. — The question has been brought up in the discussion of Mr. Richards' paper as to the sizes of pipes required for fire service, and as the discussion has seemed to run somewhat in that channel, I will take the liberty of reading a few notes that I have made with regard to the water-supply at the Thanksgiving fire in Boston, which may bear somewhat on the question of the necessary sizes of pipes.

WATER-SUPPLY AT THE BOSTON FIRE OF NOVEMBER 28, 1889.

The daily papers have given very complete details of the fire which occurred in Boston on November 28, but the question of the water-supply is, I think, worthy of our further consideration. The accompanying plan shows the outlines of the burned district, the sizes of the pipes, and the location of the hydrants. The accompanying table gives the steamers in service at the fire, their location, hours in service, quantity per minute, and approximate total quantity thrown on the fire by each steamer.

The total number of engines engaged at the fire was 56, of which number two were destroyed by falling walls soon after the fire began, and two — 16 and 18 — broke down after a few hours' service; so that the total number of steamers in service at any time did probably not exceed 52, and the number of streams thrown on the fire at any time, including five streams thrown by fire pumps of R. H. White & Co. and Hovey & Co., was not more than 86, and was probably somewhat less. The approximate quantity of water used per minute was 20,000 gallons, or at the rate of 28,800,000 gallons per day. The total quantity used on the fire during the first twenty-four hours was about 14,000,000 gallons. Seven hydrant streams were thrown on the ruins from November 29 to December 4, when the number was reduced to 4, and on December 11 the streams were all shut off. The quantity of water used by the hydrant streams during the twelve days was about 10,000,000 gallons, making a total of 24,000,000 gallons used on the fire, exclusive of leakages from services in the burned buildings. As the area of the burned district, including streets, was about 150,000 square feet, the water used during the first twenty-four hours would have covered the entire district to a depth of twelve and one-half feet.

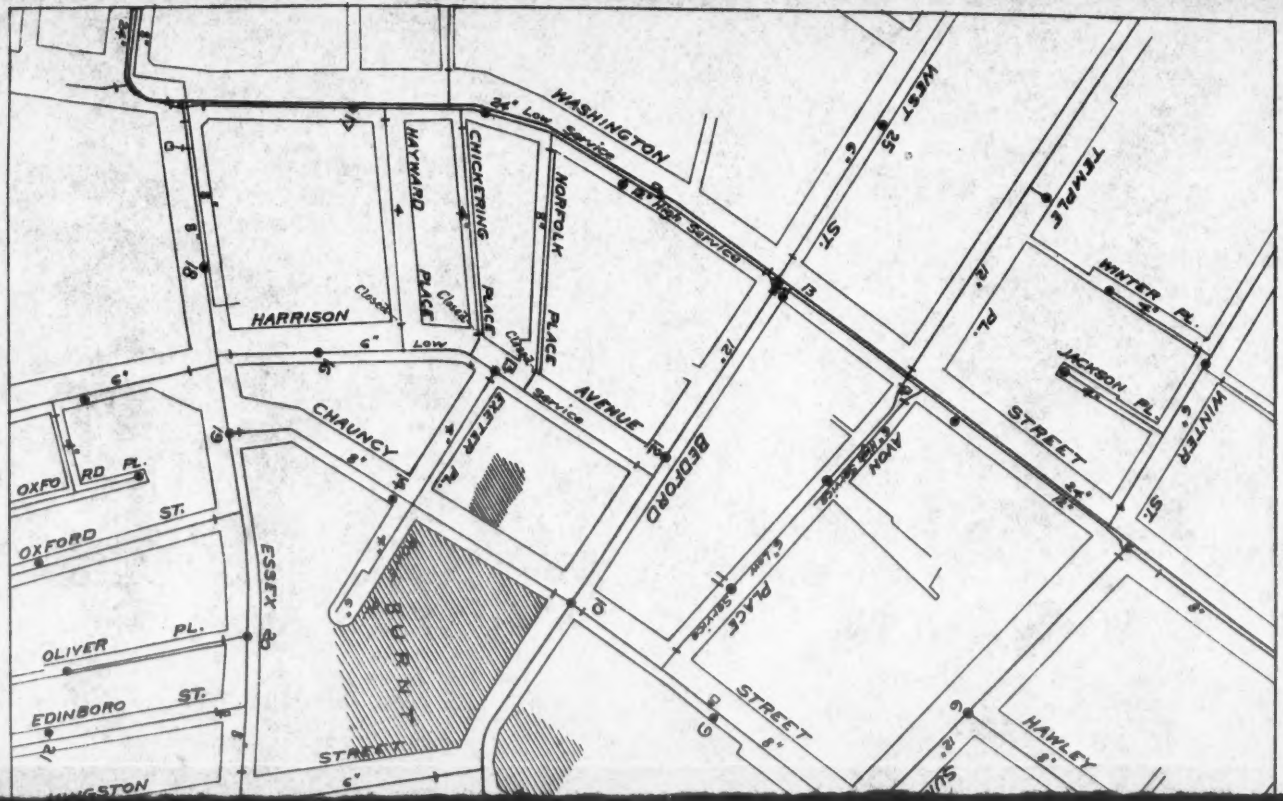
An inspection of the plan shows that this water was all taken from 25 hydrants, most of which were supplied from the line of pipe in Summer, Bedford, and Essex streets. These pipes were 12 inches in diameter in Summer and Bedford streets, and 8 inches in diameter in Essex street, and they were supplied by a 24-inch main in Washington street, aided by 6 and 8 inch cross mains connecting with 12-inch mains in Beach and Franklin streets. That the supply was ample was shown by the reports of the fire department, and also by the fact that during the progress of the fire water could be drawn from the service pipes at the top of buildings in the burning district.

A recording gauge at the water-works office, near the foot of Summer street, showed a minimum pressure of 30 pounds, or about 10 pounds less than the ordinary pressure at that point.

It appears to me that from the above data some conclusions may be drawn which will be of value. Mr. Sherman, in a paper read before this Association in December, 1888, presented such data as he was then able to collect with regard to the quantity of water used at large fires, and from the data collected drew the conclusion that 200,000 gallons per hour was an ample supply for fire service, and that the total quantity for twenty-four hours would not exceed 2,000,000 gallons.

In discussing Mr. Sherman's paper, Mr. Shedd, of Providence, suggested the use of the following formula in determining the number of streams required: —

$$\text{Number of streams} = \sqrt{\text{population} \times .005}$$


WASHINGTON
24" Low Service
12" High Service
HAYWARD PLACE
CHICKERING PLACE
NORFOLK PLACE
HARRISON
Closed
Closed
Closed
6" Low
AVENUE
Service
CHAUNCY
8"
CENTER PL.
BEDFORD
WEST 25 ST.
TEMPLE PL.
WINTER PL.
JACKSON PL.
WINTER ST.
STREET
24"
AVON PLACE
Low Service
OXFORD PL.
OXFORD ST.
OLIVER PL.
EDINBORO ST.
ESSEX
BURNT
STREET
STREET
HAWLEY
8"
6"
12"
8"
6"

PLAN
HAWLEY
ST.
SUMMER
ARCH
OTIS
DEVONSHIRE
STREET
PLACE
FORD
KINGSTON
BURNT
DISTRICT
COLUMBIA
ESSEX
OXFORD
OLIVER
EDINBORO
KINGSTON
ESSEX
LINCOLN

PLAN OF LOCATION OF BEDFORD STREET FIRE

NOV. 28, 1889.

showing System of Water Supply.

SCALE OF FEET.

100 0 100 200 300 400 500

This would give about 45 streams as the number necessary for Boston, or about one-half the number used on November 28, and Mr. Sherman's results must be multiplied by six to equal the amounts used in Boston.

The area covered by the fire was small, and I see no reason why a similar fire should not be liable to occur in any smaller city containing high buildings on narrow streets.

Another point worthy of notice is the advantage which was derived from the use of the hydrants of the Lowry pattern, which are used throughout the business section of the city. Had the hydrants been of the Post pattern, located in the sidewalk, it would not have been practicable to so place 54 steamers that none should be more than 600 feet distant from the fire. These hydrants have barrels 9 inches in diameter, placed directly over the mains, at junctions of streets where practicable, and many of them supplied eight streams or 2,000 gallons per minute.

When we consider that a steamer playing through 400 feet of hose and 1⅛-inch nozzle, with 100 lbs. water-pressure, will discharge 240 gallons per minute, while with 1,000 feet of hose the discharge will be but 170 gallons, and the effective height of the streams will be respectively 65 and 36 feet, it is very evident that it is of great advantage to have the steamers placed as near the fire as safety will permit. Post hydrants are preferable for use in districts not thickly settled; but more than two steamers cannot be conveniently attached to one at the same time.

Another advantage of the Lowry or other pattern of flush hydrant is that it is less liable to be broken by falling walls.

I wish to call your attention to the danger to the water-supply from this cause. Many buildings in Boston, and I think in other cities, are provided with "fire pipes," — pipes three or four inches in diameter, connected with the street main, carried into the building, with hose connections on the different floors, to be used in case of fire, or in other cases connected with systems of automatic sprinklers.

Consider the effect on your water-supply if the falling walls of burning buildings break off a number of these pipes, and at the same time fill the street with brick, granite, and iron, so that it is an impossibility to reach the shut-off valves.

Without underestimating the value of these pipes as a means of fire protection, I am of the opinion that the water-supply in the street mains should not be jeopardized in any manner. Even then it is not always secure. The falling walls broke completely off the 12-inch pipe on Bedford street, but fortunately the ends of the pipe did not separate, and the leakage was not large enough to affect the supply. More than a week elapsed before it could be repaired, on account of dangerous walls and the mass of brick and stone which filled the street.

At the time of the great fire of November, 1872, the number of steamers owned by the city was 21, and 45 engines from outside cities assisted the Boston department. The fire of 1872 covered an area of 65 acres.

In conclusion, I desire to call your attention to the constantly increasing demands for water which must be considered in designing systems of pipe distribution.

The consumption *per capita* for manufacturing purposes is constantly in-

creased by the demand for water elevators, electric lighting, etc. The fire departments are increasing the capacity of their engines, and the result will be that our pipe systems will in a few years require enlarging to meet these demands.

Steamer.	Location of Steamer.[1]	Hours in Service.	Number of Streams Played.	Gallons per Minute.	Total Quantity Thrown on Fire, Gallons.	Remarks.
Boston, No. 1 . . .	2	21	2	460	579,600	
Boston, No. 2 . . .	2-11	20	1	280	336,000	
Boston, No. 3 . . .	7-1	24½	2	450	656,400	
Boston, No. 4 . . .	23-10	28	2	500	840,000	
Boston, No. 6 . . .	8-3	23-	2	530	682,500	
Boston, No. 7 . . .	23-	23½	2	500	705,000	
Boston, No. 8 . . .	7-2	23½	1	250	355,000	
Boston, No. 9 . . .	10-	6	2	590	210,400	
Boston, No. 10 . . .	22	22½	2	450	634,500	
Boston, No. 11 . . .	3-13	8	2	500	149,300	
Boston, No. 12 . . .	22-14-15	8	2	500	186,000	
Boston, No. 13 . . .	10-12	19	2	500	370,000	
Boston, No. 14 . . .	9	8	2	500	135,000	
Boston, No. 15 . . .	23	23	2	510	688,200	
Boston, No. 16 . . .	24-11	4	1	250	58,200	Broke down.
Boston, No. 17 . . .	20	23	2	500	690,000	
Boston, No. 18 . . .	21-19	3½	1	240	46,800	Broke down.
Boston, No. 20 . . .	24	2½	1	250	37,500	
Boston, No. 21 . . .	24	5	1	220	66,000	
Boston, No. 22 . . .	8-	20 min.	2	500	10,000	Destroyed by falling walls.
Boston, No. 23 . . .	10-15	22	2	480	508,800	
Boston, No. 24 . . .	14-18	20	1	260	317,400	
Boston, No. 25 . . .	7-1	8½	2	520	168,800	
Boston, No. 26 . . .	8	20 min.	. .	. .	. . . .	Destroyed by falling walls.
Boston, No. 27 . . .	3	11	2	420	229,200	
Boston, No. 28 . . .	6-5	6	2	470	146,700	
Boston, No. 30 . . .	13	6½	1	200	78,000	
Boston, No. 32 . . .	6-16-15	24½	2	460	368,000	

[1] Numbers refer to figures on accompanying plan.

Steamer.	Location of Steamer.	Hours in Service.	Number of Streams Played.	Gallons per Minute.	Total Quantity Thrown on Fire, Gallons.	Remarks.
Boston, No. 33 . . .	22-15-14	22	2	480	475,200	
Boston, No. 34 . . .	19	4	1	270	64,800	
Boston, Old No. 4 . .	17-19	7	1	280	117,600	
Boston Mystic Relief,	22-19-15	12	2	520	351,000	
Boston Relief C. . .	4	15	2	430	387,000	
Brookline	13	5	1	210	63,000	
Chelsea, No. 1 . . .	2-10	8	2	600	301,800	
Chelsea, No. 2 . . .	1	6	2	600	216,000	
Cambridge, No. 2 . .	14-15	8¾	2	570	300,000	
Cambridge, No. 3 . .	12	4½	1	350	94,500	
Cambridge, No. 5 . .	20-4	7	2	460	133,800	
Gloucester	4	4	2	445	106,800	
Haverhill	11	10	1	250	150,000	
Lowell, No. 2	25-13	9	1	280	141,000	
Lowell, No. 4	4	9¾	1	280	163,800	
Malden	12	5½	2	500	175,000	
Medford	17	3	1	260	46,800	
Nashua	11	9	1	300	162,000	
Newton, No. 1 . . .	18	5	1	210	63,000	
Newton, No. 2 . . .	16	4½	1	250	67,500	
Peabody	25	4½	1	275	74,250	
Reading	25	4	1	240	57,600	
Salem	9	5	2	500	150,000	
Somerville	4-13	7	1	310	130,200	
Taunton	18	5	1	280	84,000	
Waltham	9	2½	1	325	43,875	
Woburn	4	4	2	450	87,300	
Worcester	19	3	1	260	46,800	
R. H. White & Co. .	. . . . .	4	3	700	168,000	
Hovey & Co.	. . . . .	2	2	440	52,800	

Mr. JONES. — I would like to say a word suggested by what the President has said with regard to the fire of 1872. At that time we had a great number of brick reservoirs which were supplied from our mains, and I found, the next morning, eighteen of them with 4-inch pipes from our mains leading into them, running at full head, running from the drain outlet within four feet of the ground, and those must have taken from the 12-inch and 6-inch pipes a large amount of water.

Mr. DARLING. — I want to say one word. I didn't have any fire at my place, but I had occasion to test the hydrant service there last September on a line of 4,040 feet of 20-inch main, what we call the force main, running from the pumps to the reservoir; and we played 70 fire streams and maintained 80 pounds pressure. The standing pressure was 110 pounds, and when the 70 fire streams were playing, we had 80 pounds pressure during the time we played, — eight minutes. I merely made the experiment to see what service we could get out of the hydrants there. We played from nine 6-way hydrants and eight 2-way, making 70 fire streams.

The PRESIDENT. — I will now call upon Mr. Tidd.

Mr. TIDD. — I believe you did threaten to do that at the last meeting, or you asked me then to prepare a paper. I told you I should have no time to write anything, but after listening to the very able paper of Mr. Freeman, on fire streams, it occurred to me that there was a duty which we had, who were interested in water works in connection with the fire department, to have some understanding with that department as to the amount of water they could draw from any one particular portion of the service, in case of fire. Now, I suppose there are no works built, and probably never will be, so large that a certain number of streams might not reduce the pressure to such an extent as to destroy the efficiency of the streams. Of course it could be arranged easy enough between the fire department and the water department, so that they should understand that in certain quarters and from certain pipes, only a certain number of efficient streams could be drawn. If you draw one too many, or two too many, you reduce the pressure to such an extent as to render all the streams practically useless. It seems to me that it might be easily computed, or if that cannot be done, on account of various connections, curves, corners, and so forth, it might be easily ascertained by experiment. In the case of Lynn, for example, I understand the normal pressure there, which was somewhere about sixty pounds, was reduced to something like thirty at the time of the fire, — to twenty-three I am now informed, — even worse than I had understood. Now, it is possible that if they had reduced the number of streams they were using it might have rendered the others more efficient, so that the streams that were left might have been more valuable and made more impression upon the fire than the whole number which they did use. I don't mean to say that that is the case, but it possibly might have been. It seems to me that is a direction in which we ought to spend some talent and some attention. It is a thing easy to be done, and I regard it as very important. I have known instances — one case I have particularly in view, on a very small pipe, a 4-inch pipe — which ought to be legislated against. We have them in some towns, and in large numbers; however, this was on a 4-inch pipe of considerable length, where a house took fire and burned down between two engines, either one of which would have saved the building if the two sets of firemen hadn't insisted

upon playing upon it at the same time. (Laughter.) A 4-inch pipe, under the pressure they had, would have been just enough to have carried one stream to the house, and one stream would have saved it; but neither company of firemen would let go, and between the two the house burned. (Laughter.) I merely mention that to illustrate the point I wish to make. It seems to me this is a thing of importance, and I would like to hear a discussion upon it by some of the members.

Mr. JONES. — I merely want to ask a question in regard to one thing. Mr. Freeman spoke about a 4-inch pipe for fire purposes, and he made the remark that the man who laid such a pipe as that ought to be hung.

Mr. TIDD. — I agree with him perfectly. (Laughter.)

Mr. JONES. — Now, as I have put in a great many of them, and as our President has also, I should like to know how many more candidates for the gallows there are here. (Laughter.)

The PRESIDENT. — I think Mr. Freeman's meaning, in that statement, was a line of pipe surrounding a mill, — a long line of pipe of that size, and not a short pipe from the main into the mill.

Mr. JONES. — I am glad you so understood it, for I supposed I should be hung before a great while. (Laughter.)

Mr. TIDD. — In my reference to a 4-inch pipe I did allude to a long line in a street. I consider that four feet of 4-inch pipe is a ridiculous length; but this was something over 1,000, perhaps 1,500 feet, the one I alluded to particularly. I wish there was some law which would prevent the use of 4-inch pipe for any length as a street main.

The PRESIDENT. — Mr. Kimball, of Somerville, I think, promised to give us something.

STEALING WATER.

BY

GEO. A. KIMBALL. Jan. 8, 1890.

Mr. KIMBALL. — I did not promise, but you insisted I should say something. What little I have to say I have not had the opportunity to put in writing, and therefore you will bear with me if I make a few rambling remarks. The matter I propose to mention is something I investigated several years ago. I think, perhaps, it would be best not to mention the name of the place or the names of the parties connected with it. The subject is "Stealing Water." (Laughter.) It occurred in a city not more than twenty miles from Boston; it was not more than twenty years ago, and the parties connected with it are nearly all dead. There came into the office of the superintendent of the water works, one day, a man somewhat under the influence of liquor, and he asked the superintendent what the fine was for stealing water; and went on and made certain statements by which it appeared that the manufacturing establishment with which he had been connected for a great many years had discharged him for dissipation, and he came to tell the superintendent that this establishment had been stealing water for ten years, by a very systematic arrangement. Investigation showed that from the street main there was carried into the yard a four-inch pipe, and about sixty feet from the line of the street, in the yard, was a meter. The pipe continued beyond the meter to the other end of the yard, and then ran off at

right angles to a well. From that well a pipe was carried back to a point nearly opposite the meter, and about sixty feet distant. This well had a pipe connected that was arranged with a pump, and the water for the establishment was supposed to be pumped from that well.

At some time, and in the night, a connection was made from the end of the pipe to a point between the meter and the street, and the water was taken from the pipe from the water-main and carried around the meter, as we might say, into the well. To go upon the premises and examine, you would see that the water was pumped from the well, and would suppose that all the water used by this manufacturing establishment had gone through the meter, when really the well had proved insufficient, and the proprietor of the establishment had taken this means to replenish it. A large amount of water was allowed to pass through the meter each quarter, so the inspector might not discover that anything was wrong, and the bills at that time amounted to about $1,200 a year.

When this was discovered, — I might say it was discovered soon after the death of the proprietor of the establishment, and was readily acknowledged by those then in charge that such a thing had been going on for a good many years, — when this was discovered and the fraudulent pipe cut off, the rates increased to $3,600 a year, making a difference of $2,400. This fraud had been going on for ten years, making a total amount of $24,000. Further investigation of the affair showed that at a prior time this establishment had been connected with the water works of another city, — it was located near the borders of another city, and this other city had found that they had been stealing water, and imposed a fine upon them of $500, which they had readily paid. This was ten years previous to the discovery of the matter I am referring to. They had readily paid the fine of $500, and said they didn't want any more water from that city, and then made this little arrangement, which I have described, and during the ten years had succeeded in stealing water to the amount of about $24,000, and perhaps more, — nobody knows how much. I think, gentlemen, superintendents, you can possibly gain something from this experience. The moral is, always keep your meters in the streets. (Applause.)

The PRESIDENT. — I suppose the people in other parts of the State are honest and never do this sort of a thing, but I am going to ask Mr. Hawes, of Fall River, if he ever heard of any such case in Fall River.

Mr. HAWES. — Not on so large a scale as that, but we did find one case there. (Laughter.) There was a tremendous leak in our water one day; the water went down at the works, and they telephoned to the office and wanted to know what was the matter. No one at the office knew what the matter was; they knew there was no extra draught on the pipes; but our superintendent, Mr. Kieran, had a pretty good idea where the trouble was, as the water in the ponds was very low, and it was almost impossible at some mills to get a supply for condensing water for the engines. The main went down two streets, and then there was a street right across where the pipe went, and nothing to connect with it up in this cross street except a certain mill. So our superintendent goes up and shuts off the water in that street, and pretty soon the superintendent of the mill comes out and says, "What is the matter here?" — "I've lost a nut," Mr. Kieran said, "and we can't find it." — "Come right in the machine-shop and get one." (Laughter.) — "Oh, no hurry." — "Suppose our mill should get a-fire?"

— "We have a man at each end to let the water on if there should be an alarm." Very soon he came out again and said, "Come into the shop and we will give you a brass nut." I guess he would have given a gold one or a silver one. (Laughter.) Mr. Kieran says, "I guess we will find it before a great while." He had one in his pocket all the time. (Laughter.) Pretty soon the mill shut down and the boys came out. "What's the matter, boys?" — "Can't get any water to run the engine." (Laughter.) Pretty soon the superintendent came out and asked him how long before he was going to let the water on. "In the course of an hour." — "Well, but," he says, "we want it." — "What do you want it for?" — "Well, but we can't run." — "But you are not getting your supply for your boilers from this?" — "No." — "Nor you are not condensing with it?" — "No." — "Well, what do you want?" — "Well, we want the water on." (Laughter.) The mill didn't start up till the water was let on, and then we found he was drawing water from an 8-inch pipe into his condensers. And we investigated and found that that pipe had been connected, so that they had used at least $3,000 of water, as near as we could estimate. It was put on with the knowledge of the superintendent, and the treasurer ordered it on, but, like Mr. Kimball's man, he had died. (Laughter.) It was generally considered he wanted more water after he died than he did when he was alive. (Laughter.) However, we investigated, and the engineer came before us and testified that he didn't use water for condensing purposes. He was asked if the water sometimes got low in his trench. "Yes, quite often." — "Well, how do you run?" — Well, he ran without any condensing water. — "How do you run your condensing engine without any condensing water?" — Oh, he could run it a considerable time. — "Well, how long?" — Well, he didn't know. — "Two hours?" — "Yes." — "Five hours?" — "Yes." Finally he went so far as to say he could run it three-quarters of a day without any condensing water in his condenser. Well, that was a new theory, — something new to us. However, the new treasurer came forward, and he said he had no doubt the water had been stolen, and whatever we thought was right they were willing to pay; and we sent in a bill, and he paid us, I think, some thousand dollars. I think that is what we estimated had been used while he had been in charge.

The officers of a corporation seem to feel very often that they have a right to steal from the city. If a boy stole a handful of cotton from them, they would have him arrested and sent over to the New Bedford jail; but they think they have a perfect right to steal a thousand dollars' worth of water from the city. It got so serious with us that we found we had got to do something desperate. We would find, every once in awhile, a mill had put in a new set of water-closets and connected them with the fire-pipe; or had put in this and that, and made connections with the pipe; and we finally employed an inspector to go around, and we sent notice to all the mills that they must put in meters. Well, their supply pipes were from ten to twelve inches, and the meters were going to cost from $800 to $1,000 apiece, and the mill folks got frightened. So finally we made them have a pipe entirely separate from the one for fire purposes, — for supplying water for drinking, washing, and so forth, — and have it so we could look it all over any time we were a mind to and inspect it, and put a meter on that, and then let them use the other for fire purposes entirely, and nothing else. But once in a while we will find that they have tapped the fire-supply pipe; and then the superintendent will say he don't know anything about it, that it was the bull-

headed plumber who did it (laughter), and they think it is rather hard when we require them to take it out and plug up the hole. We have to watch them all the time, and even then some of them will hook on. If you get pay for all the water you are very lucky.

Mr. JONES. — I should like to ask the gentleman who introduced this subject, if the intoxicated man had been stealing water?

Mr. KIMBALL. — I can't say, Mr. Jones, as to that. There is one other little fact I neglected to mention. During these ten years, one year the proprietor of the establishment allowed an unusual amount of water to pass through the meter, so that their bill was quite a little more than $1,200, perhaps several hundred dollars more, and when he received his bill he came up to the water office and said that something was wrong, that he hadn't used as much water as that, though all the time he was stealing it at such a wholesale rate; he said he hadn't used as much water as that, and he wouldn't pay the bill. The bill was referred to a committee for investigation. The chairman of the committee was a very smart, bright man, and they went up to the factory and spent quite a long time, several hours, examining to see what the difficulty was. They went to the well and examined the pipe and the gates, and so forth, and reported back that some mistake had been made, and that there should be an abatement of the bill, and so it was reduced to the usual amount.

The PRESIDENT. — I will now call upon Mr. Fuller.

THE LAYING OF A TEN-INCH PIPE IN LEICESTER, MASS.

BY

F. L. FULLER. Read Jan. 8, 1890.

Mr. FULLER. — I thought, perhaps, I might interest the members by telling them a little about a supply that is being put in for the town of Leicester. It is a gravity supply, and is obtained in the adjoining town of Paxton, which is about 5 miles distant in a straight line, and somewhat longer by the pipe line. Where this supply is obtained is a sort of a level plateau, and the pipe line is nearly level for a long distance; in fact, in about 10,000 feet we are only able to get a fall of about 10 feet in a 10-inch pipe. It is being laid about the line of grade, and the upper end of this pipe, which is practically a siphon pipe, will be about 7 feet below the water in the large well, which is to be built at quite a large spring which is to furnish the supply. The pipe is laid through about 3,000 or 3,500 feet on the bottom of a pond. The pond has been drained down, and this pipe has been laid in the bottom of the pond, with a cover varying from 2 feet to 6 feet, and in some places it has been necessary to use piles. We have used piles 16 feet in length, the longest of them, and running down to 3 or 4. The short piles have been driven with a beetle, and the longer ones have been driven by using a weight weighing about 400 pounds, which has been attached to the block and fall of the derrick which is used for laying the pipe. There has been no particular trouble in getting these piles down, and after they have been driven down to the solid bearing they have been cut off level, and a cap 5 inches square placed across the piles, which were about 22 feet on centres, and this cap secured to the piles by putting a pin, an oak trunnel, through. Being laid below the pond, and when above the pond, in ground that is comparatively wet

most of the time, this pipe will be under the ground water, and probably there will be no serious trouble in using it as a siphon. The pipe is to be tested so as to make sure it is tight; and I might add, as to the weight of the pipe, it is a 10-inch pipe, and it weighs 50 pounds to the foot, which is pretty light. There has been some trouble from breakage in cartage, as has been referred to before.

The deepest cut will be about 20 feet for a short distance, and 15 feet for quite a number of hundred feet. I had only two bids for doing the work. One man bid $1 a foot for laying, and the other bid was 23 cents a foot; so you can see there was considerable difference. This pipe runs down through a stream at the head of what is called Arnold's Pond, and in the 2,000 feet below this is this deep cut, which I have spoken about, of 20 feet, and then the pipe pitches down quite steeply, quite sharply, to the village of Cherry Valley, which is just above Worcester, where there will be a head of about 400 feet. Then the pipe runs up into the village of Leicester, where there will be about 100 feet head; and it is proposed to locate a stand-pipe on the hill just to the north of the village, where the ground is about 40 feet lower than the surface of the water in the spring, and here a distributing reservoir will be built, of 30 or 40 feet in diameter, and about 40 feet high. I don't know as there is anything quite like it in this vicinity, and I didn't know but what it would interest some of you who are here.

Mr. STACEY. — I would like to inquire, if it is not asking too much, whether the dollar or the twenty-three-cent man got the job. (Laughter.)

Mr. FULLER. — I will answer Mr. Stacey by saying that the contract was given to the lowest bidder, and he is doing a pretty good job, and I think will finish the work satisfactorily, although he won't make much money.

Mr. WINSLOW. — I would like to ask Mr. Fuller what depth he is laying the pipe, and what he does, — whether he furnishes the labor, or the labor and lead, for that price?

Mr. FULLER. — The cover in the pond, in a few places, is perhaps not more than a foot or two, and it increases, so that in some places there is a little over six feet cover. As to the work the contractor is doing, he is furnishing the lead and everything that usually goes with pipe-laying. At the prices he gets for piles, and the timber foundation which we have to use in some places, probably there is some little profit for him, which helps him out on the 23 cents per foot for the pipe-laying. If I remember rightly, — I haven't the figures with me, — he gets 12½ cents a foot for the piles driven, which are supposed to be 5 inches at the small end and 6 inches at the large end, and at the rate of $75 a thousand for the caps in place. Of course that don't amount to a great deal, so he can't make very much on these items.

The PRESIDENT. — I think Mr. Winslow, of Waltham, agreed to say something this afternoon.

EFFECT OF WATER-HAMMER ON CEMENT-LINED PIPE.

BY

GEO. E. WINSLOW, Waltham, Mass. Read Jan. 8, 1890.

Mr. WINSLOW. — What I have to say is not really in the line of what has been spoken of here, although a good deal has been said about the effect of

water-ram on pipes, and it may be pertinent in that connection. We have in our town a good deal of cement pipe, something over half of our pipe, and in times gone by breaks were very frequent. In fact, when the works were first put in they would very seldom have a fire, or even test the hydrant, without bursting a pipe or, perhaps, pipes. It got so bad there at one time that there was one man who was connected with the water works, — that is, when it was done under the old town form the work was done by contract, — who was made responsible to go to the hydrants and open them for the fire department, and close them for the fire department, to see if this bursting of the pipes could not be prevented. Of course that didn't work. At the time I took the works, which was eight years ago, we had leaks there, a great many of them, although the bursts from operating the hydrants were few. I would say that, up to that time, the firemen in testing the hydrants, if they found they went hard or were in any way out of order, would take off the cap and try to remedy the difficulty themselves. The style of hydrants which was in use at that time was the old style of Boston hydrant. They would take off the cap and oil the spindle and nut, and so forth, and put it back; and the consequence would be they would leave them, perhaps, a little loose, and when they shut the valve by the centre of the pressure of the flow, it would bring the valve down to its seat with a sudden motion, and produce quite a water-hammer. After I took the work I objected to their doing anything of the kind. I told them, if the hydrants were out of order I preferred to know it and to fix them myself, and after a good deal of work I made out to get it arranged in that way.

Well, since I commenced to take care of them myself, I have looked out for this very trouble; that is, looked out for any end-shake or back-lash in the valve-rod. I found in all leaks that the pipes were rusted badly, and the cement in a good many places was cracked, which allowed the circulation of air or water to come in contact with the shell of the pipe. I found, also, in taking out pipes, that the cement in all cases was wet through to the pipe, and the pipe would be wet; but I made up my mind that the circulation of water was so slight that it could not rust it, or, in other words, it wanted circulation of the water or air on the iron in order to rust it, and as soon as that happened it would weaken it, so that any heavy, or even slight, water-hammer, of course, would burst it. When I found that was the trouble, of course I knew there was a lot of it which would show in time to come, and I wanted to stop any further trouble of that kind. So I put a man on to all of the old Boston hydrants, and chipped off the top so as to bring the cap down closer; and I have found that, with a very few exceptions, I could take up from a sixteenth to an inch end-shake. Now, a sixteenth or an eighth of an inch movement of that valve, when it got to the right point, shut off a large supply of water, which, moving at the velocity that it did, made a very heavy water-hammer, and I have found main pipes broken by the shutting of that at quite a distance from the hydrant, — perhaps 1,200 feet. Since I have had those hydrants fixed I have found that my leaks have decreased very rapidly. Before that was done, the leaks would run up to 25 or 35 or 40 a year. They have decreased now; so this last year we have had, I think, four leaks on my cement pipe, which you might say could be traced to the action of water-hammer in times past. Last year the leaks were very few. I don't say that the trouble is all ended, because I think the damage has been done, the pipes have

been weakened, the cement cracked, and the pipes are rusting and will come out; but I do think that if that water-hammer had been stopped in the first place our cement pipes would be in a great deal better condition to-day than they are.

I have heard some of the members speak about using elevators. I have but one elevator in Waltham connected with our mains, and that is from a cement pipe. It is connected with a 2-inch pipe; it was put in by a Worcester firm, and they showed me the valve they were going to use, and I told them I should require a relief valve on the service pipe close to the valve the elevator was worked with. The man in charge of it wanted to know why, and I told him because they could shut the valve so quick that they could create a water-hammer that would burst our main. He thought it was foolish; but I said, "Our pipes are cement-lined pipes, the iron is thin, and it hasn't got the strength of cast-iron pipe; if it had, perhaps it would not be necessary to take this precaution." Well, they finally put it on, and we have had no trouble from it, for there is no water-hammer; if there is pressure enough so that we might get a water-hammer, the water escapes through the relief valve.

We also have a stand-pipe in Waltham for the Fitchburg Railroad, and Mr. Turner, the chief engineer of the road, wanted to connect with our mains and put on a slow-moving gate; that is, a gate with a fine thread, so they would shut the valve slowly, so they couldn't produce any water-hammer. He wanted to get rid of a tank which was an eyesore in front of the depot. I told him I was afraid, that with the men who generally work valves on a railroad, they would burst our pipe by increasing the pressure rapidly by a sudden closing of the valve. He said they wouldn't do it, and he said, furthermore, "I will put on a good, careful man, and he will be responsible." But I saw one of those careful men operate a valve in Worcester at the Union depot, one day, when I was up there to see what kind of an arrangement they had, — to see what I could do for the Fitchburg Railroad. The express train came through there along about twenty minutes past three in the afternoon, and I knew they would water-up, and so I went to the depot to see them do it. The water was turned on, and the fireman didn't pay attention to his business as closely as he ought, and the consequence was, the tank got pretty near full before he noticed it. "Shut it down, you will overflow in a minute; hurry up, hurry up!" And they did hurry up, and that valve was shut just about as quick as it could be shut. That was the careful man who was taking care of that valve. Now, I made up my mind that would be the case in Waltham, so I told Mr. Turner that if he would put on a relief valve which would be large enough I should be happy to put in a service for him. He didn't like that idea; and he is a pretty set man any way, as well as myself, and the consequence was, we went through that fall and winter without any stand-pipe. In the spring he came to me, one day, and he asked me when I was going to put in the service for him. Said I. "Just as soon as you can conclude to put in a relief valve. As I understand it, you want a 6-inch pipe taken off from the street main, run through a 4-inch meter, and then a 4-inch pipe to your stand-pipe?" "Yes." Said I, "As soon as you will put that in, and put in a relief valve close to the valve which operates the stand-pipe, and that shall be a 3-inch valve, and not be set at over ten pounds above the standing pressure, just so soon we will put it in for you." Said he, "I will put in anything you want." And the consequence was he put it in, and we

never have had any trouble, as yet; the pipe has been all right, the meter has been all right, and everything has been all right. My idea in regard to keeping pipes from bursting is to avoid water-hammer as far as possible, especially with cement pipe.

Mr. JONES. — As the gentleman has spoken about cement pipes, I would like to make one suggestion with regard to that subject. At the last meeting, I think it was, Mr. Nevons and Mr. Richards were talking about cement pipes, and Mr. Nevons made the remark that he had some number of miles of cement pipe he would like to sell, and that he would throw in the cost of laying the pipes if he could sell them. As this is the only time I have heard anything said about cement pipes, and as I have been asked a great many times during my experience in the water works, and since then, what I thought of cement pipes, and never having had any experience with them, I could not tell, I should be glad to hear something more about them. I suppose there are associate members here who lay cement pipes, and who can say something on the other side of the question. When I say the other side of the question, I mean my side is very unfavorable to them, so much so I would be glad not only to throw in the laying, but, if that wasn't enough, I would throw in my situation as superintendent. (Laughter.)

Mr. BARRETT. — If I was able to, I should like to enter into a discussion on the merits of cement-lined pipes. At some other meeting I shall be willing to try to hold my end up. Our superintendent will back me up, and we can tell you why we believe in it in Woburn.

Mr. NEVONS. — I am very much surprised that any member of this Association should want to open the cement-pipe question here again. (Laughter.) I was called on to say something about it once, some ways from home, and I said there that this Association had discussed the matter, and had decided that cement-lined pipe was the best pipe to use, if it was only made right. There seemed to be a good deal of surprise manifested when I made that statement, and so I went on to say, that in order to have it made right you wanted to have the iron somewhere from three-quarters of an inch to an inch thick, and then you could put the cement on just as you were a mind to. (Laughter.)

Mr. ALLIS. — The gentleman who read the paper spoke of the breaking of the pipe caused by the operation of the hydrants. I should judge, from what he said, he thought the water-ram was what caused the breaking, and I should like to ask if that is what he meant, — that that was the only trouble? It would seem to me hardly in accordance with the experience of myself and others, who have a large lot of cement pipe which we wish we hadn't got.

Mr. WINSLOW. — I wouldn't say it was the whole cause of our bursts — yes, I will say of the bursts, but not of the leaks in our cement pipes. I know of one line that was built by contract eight years ago this last summer, and when they turned the water into it it leaked considerably. The water that leaked out of that laid along in between the outer covering, and perhaps the inner covering, so far as that goes, and the cement, and would rust the iron so that in time it would weaken it. But in cases of bursts, I think they were occasioned principally by the shutting of the hydrants, or some outlet where there was a large flow, suddenly, and creating a water-hammer.

Mr. ALLIS. — I have had a good many breaks in a year, having about 54 miles

of this pipe, and I have had experience of this kind: we will dig down and find the water running out of a gap two or three feet long, and the iron as thin as a piece of paper, and thinner, too, and the rust all around the whole length of the pipe. It appeared to me that the pipe had been rusting for a good many years, and it finally reached the very last breaking-point, and away it went. In nine cases out of ten, in my own experience, the breaks have been of that character, where the pipe had deteriorated till there was nothing left of it. Of course, we all know that that might be owing in many cases to poorly laid pipe, and I heard after I took charge of our water works that the contractor sometimes, when he was in a hurry, would stick the pipe into the ground without waiting for the cement to dry, and of course we couldn't expect such a pipe to last many years. I think there is a chance for good cement-lined pipe to last quite awhile; nevertheless, at the present price of cast-iron I would not advocate laying any cement pipe.

Mr. WINSLOW. — There are a great many of us who have cement pipe in our systems of water works, and we have got to take care of it as best we can, because we haven't got the money to replace it with cast-iron at present.

The PRESIDENT. — There is one question which has been brought up in discussing the size of pipes, and that is the question of fire pipes, which I wish to have carefully considered, because I think it is one which will be of great importance to all of us, and especially to those in the larger cities, where the use of fire pipes is more general than it is in smaller places. In Boston we have a very large number of these pipes now, and since the November fire I have had a dozen applications for 4-inch pipes. The other day an application was made for four 4-inch pipes in one building. The question to be considered is, whether the introduction of these pipes, which is practically demanded by the fire-insurance companies, will not have the effect of impairing the efficiency of the water-supply in case of large fires; in other words, whether it will not have the effect of defeating the object which is had in view. There is no question but that the fire pipes in buildings which are destroyed by fire will be broken off and the water will escape into the buildings. It is a practical impossibility to shut off the water in the case of a large conflagration after the walls have fallen, and a large number of these pipes will be sufficient to cripple any system, I don't care how large it is; that is, any system which is in use to-day. It is my opinion that the water for fire supply should be kept underground, and where it will be protected as far as possible from any danger. I think Mr. Haskell, of Lynn, from what he has told me to-day, has some opinions on this point, and I don't know but other gentlemen may have. I think it is a question which is bound to arise between the water companies and the insurance companies, and it is a question that must be discussed and settled. If Mr. Haskell has anything to say, we would like to hear from him.

Mr. HASKELL. — I was not intending, Mr. President, to say anything whatever on the subject to-day, but I will say this, that at the commencement of our fire, knowing there was going to be a large fire, I started out four men to shut off all the large pipes that we could shut off. We had quite a good many 4-inch elevator pipes, and a good many 2-inch and 1½-inch pipes, and we shut all of them off. The fire-sprinklers I didn't dare have shut off, for the reason I was afraid it might complicate the insurance. A man having a fire-sprinkler in his

building, and it being tampered with, I didn't know but the city might be called upon to pay some of the insurance, and for that reason I didn't have any of them shut off.

We had one elevator pipe broken off entirely by the fall of the building, a 4-inch pipe, and till ten o'clock the next morning the water was allowed to run out of that pipe freely. There was one fire-sprinkler we were not able to close after the building had fallen, for there was about six feet of brick on the shut-off. In all cases where we put in 4-inch sprinklers we put the shut-off as close to the main pipe as we can, and we shut off all of those with one exception, and, as I say, there was six feet of brick on top of that and we couldn't get at it. One man was quite severely burned in trying to shut off one of these sprinkler pipes after the building had got so thoroughly on fire that there was no danger of the insurance question coming up. We only had two large pipes to draw on for our water-supply, and we did suffer from a great loss of water.

Now, as to the question of the future demand upon water-supplies, I will state the position that the city of Lynn is in to-day. On 70 feet of one street we have got five applications for 4-inch sprinklers to be put on an 8-inch pipe. Now, if there should be, as I think there will be, three applications on the other side of the street, — I am discouraging them as much as I can, — there would be in 70 feet, on a street which is only 50 feet wide and supplied with an 8-inch pipe, eight 4-inch sprinklers demanded.

A STUDY OF ALGÆ GROWTH IN RESERVOIRS AND PONDS.

Read before the Association, February 12, 1890.

BY

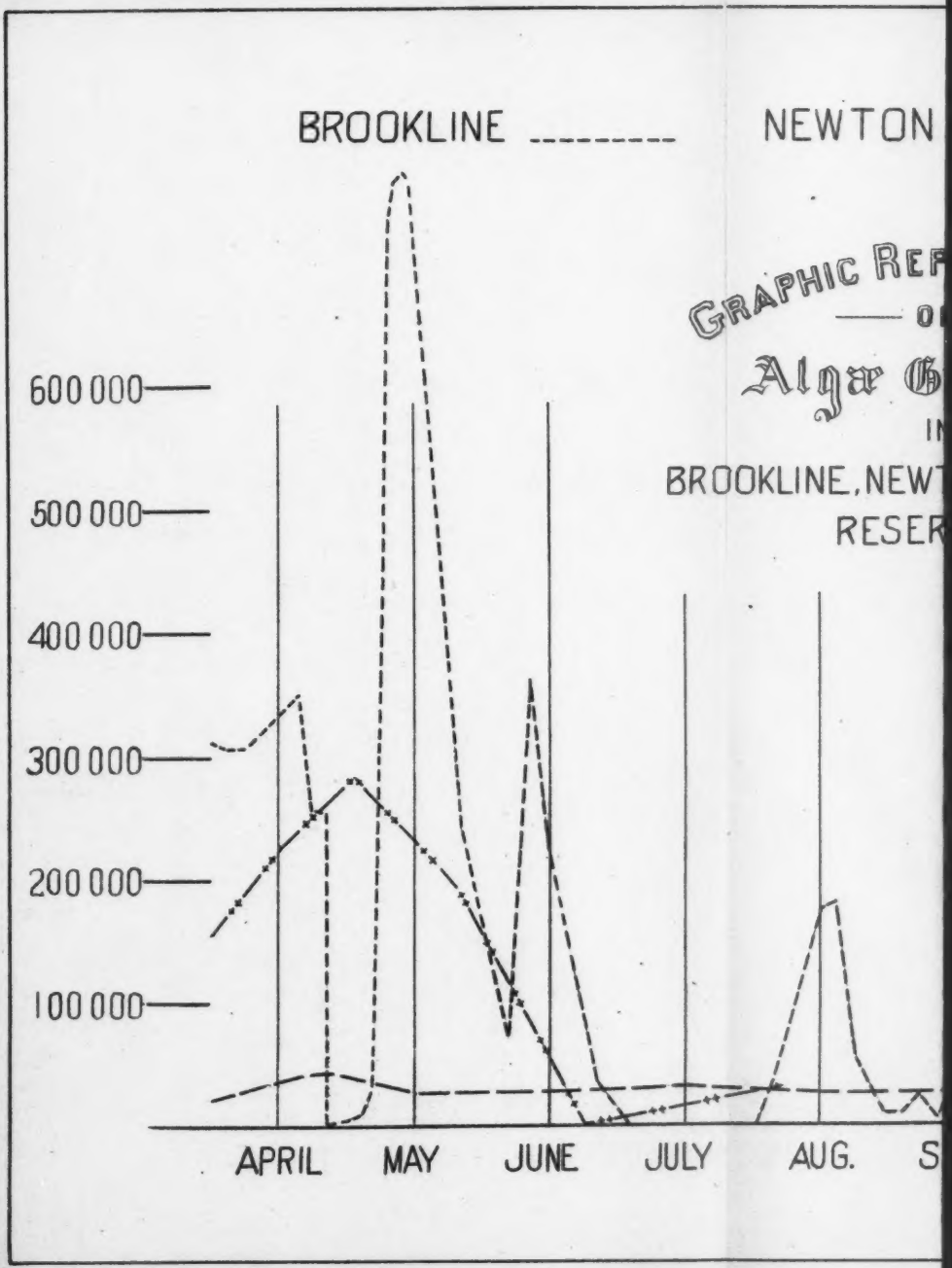
F. F. FORBES, Supt. of Water Works, Brookline, Mass.

Probably there are few superintendents of water works in this country, or in fact in any other, where the water is stored or drawn from basins or reservoirs exposed to sunlight, who have not had more or less trouble from minute water-plants, called algæ, which often find in these basins and reservoirs an excellent place for their growth.

In some waters the conditions are so favorable for their development, that by their rapid growth and as rapid decay the water is made exceedingly disagreeable to the taste and smell, and the whole system is a failure as far as delivering to the consumer a pleasant and wholesome water, which is the chief end in view.

At first thought, it seems hardly possible that such minute organisms as these plants can do so much mischief, and it appears to me that any facts which may be learned from a study of these organisms cannot fail to be of interest, not only to those closely connected with the management of water works, but also to the consumer, who is obliged to take such water as flows from his faucet.

This afternoon I will invite your attention to a brief account of the few inves-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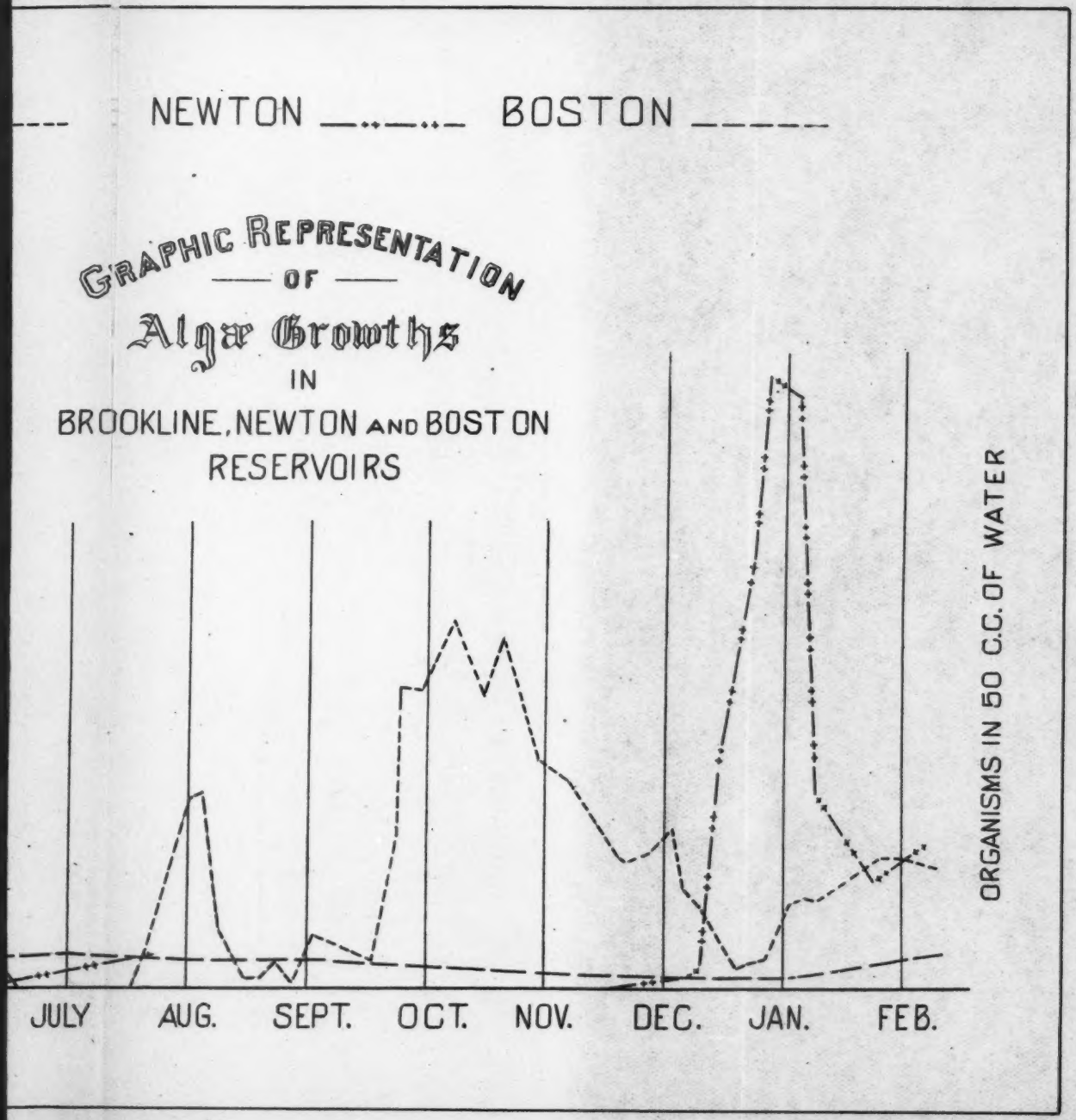
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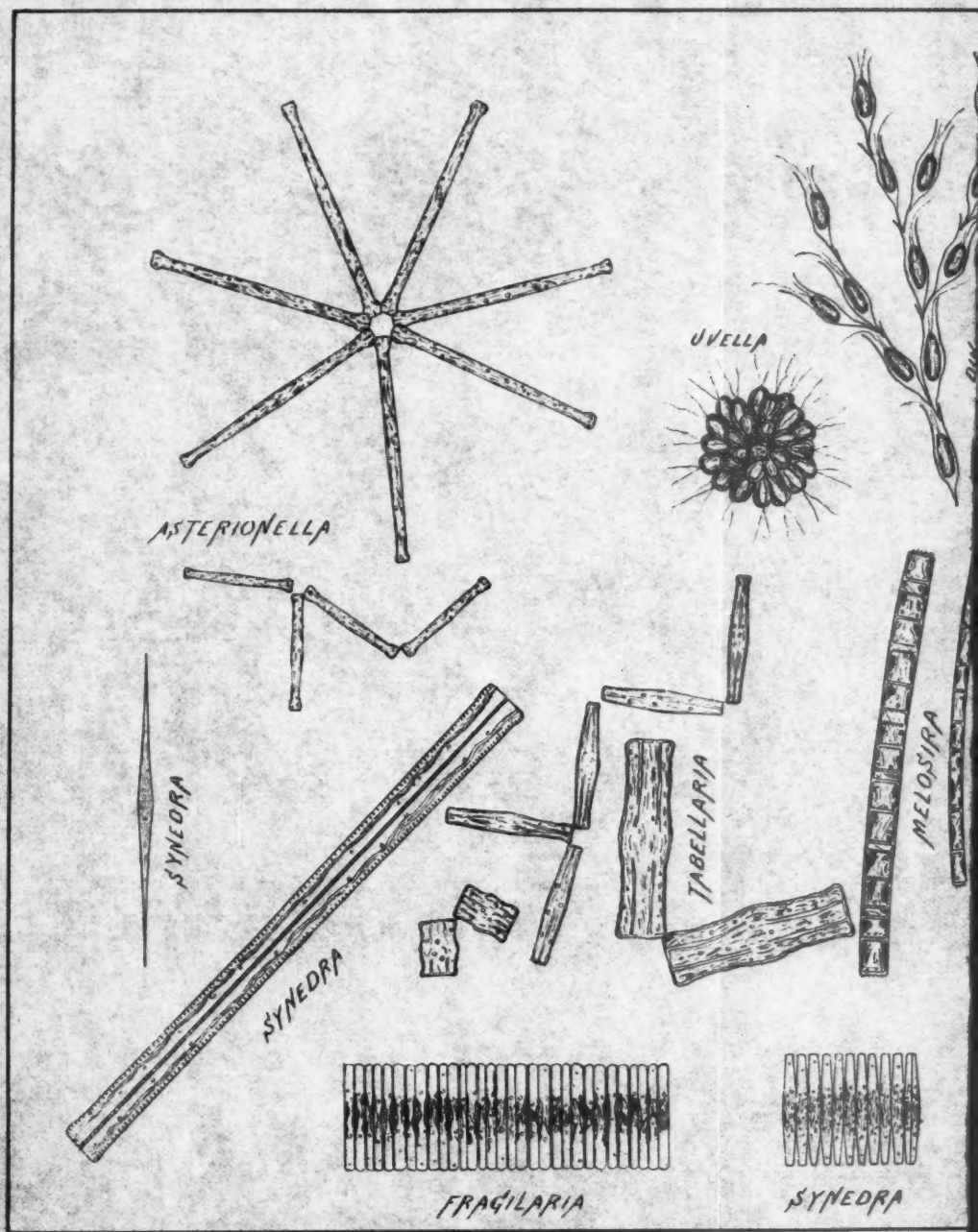
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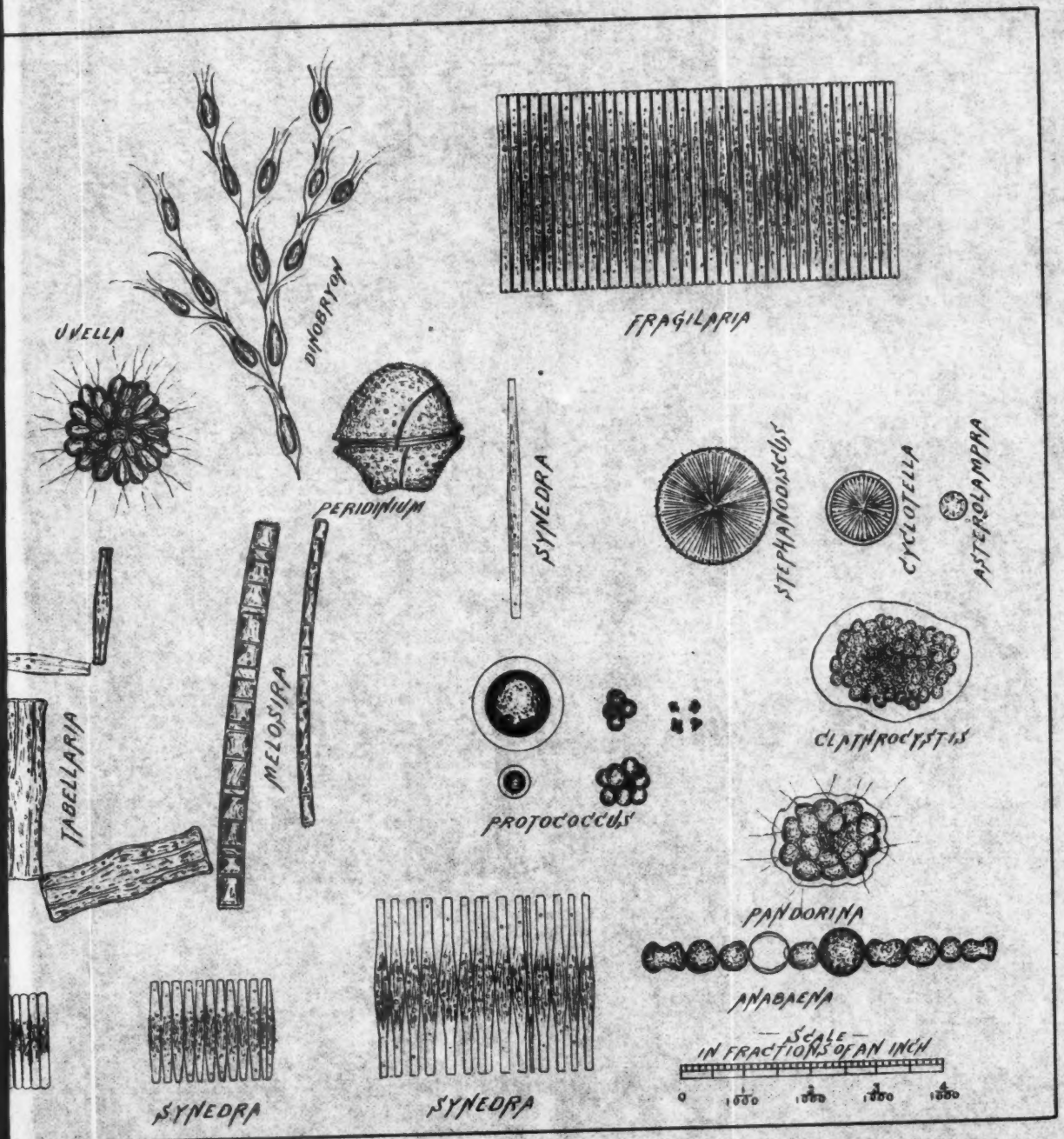
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tigations which I have made in this direction, and also to information which I have obtained from the labor of others.

It has often been remarked, that as cold weather approaches, the algæ which have flourished during the summer would disappear, and reasoning from the habits of plants which are visible to the naked eye, such a remark would be correct. In early spring we see the trailing arbutus, the violet and dandelion, later these give way to the daisy and chiccory, and still later, the gentian and golden-rod dot the meadows and hillsides; and then the autumn frosts turn the forest leaves, kill the flowers, and leave the fields brown, soon to be covered with the winter's snow. So accustomed are we to these changes, which the seasons bring to the visible vegetable world, that we should be very much surprised to see, on some cold winter's morning, the forest trees in full leaf, and the summer flowers show their faces through the frozen ground; yet nearly all kinds of algæ flourish as well in winter, even under the ice, as in the warmer days of July and August.

Furthermore, we all know that the trees put forth their leaves only in the spring, and the golden-rod blossoms only in the fall; but a certain algæ formation may appear in one body of water in July, this year, and perhaps in any other months the following year, or not at all, while in a neighboring body of water the same plant may devolop in just the reverse order.

During last winter melosira was quite abundant in the Boston reservoirs, but as spring came on it disappeared almost entirely, and from a study of this diatom in this body of water alone one might conclude that warm weather was unfavorable to its growth; but a sample from Pawtucket reservoir, taken Oct. 3, 1889, showed this diatom in very large numbers and in a healthy condition, so we must conclude that the change in temperature alone, only as far as it affected its food-supply, or made it more favorable for some other plants, had little or nothing to do with its disappearance.

To further illustrate how little influence change of temperature has upon algæ growths, I will now call your attention to the results of microscopic examinations of water from Brookline reservoir of Brookline Water Works, from the Boston reservoirs in Boston and Brookline, and from the Newton reservoir of Newton Water Works; and, for convenience of this paper, commencing about March 15, 1889, and continued to date. The examinations of the water from Brookline reservoir were made about every 5 days, from the Boston reservoir once each week, and from the Newton reservoir at much longer intervals, with few exceptions.

On this chart, which you see, the number of organisms found are shown graphically.

It will be observed that about April 10th a growth started in the Brookline reservoir which increased remarkably, and reached its maximum in about 20 days, then growing less, with the exception of a short time immediately after a quantity of fresh water had been pumped into the reservoir, until nearly all the algæ disappeared, and during the warm days of July the water was almost free from these plants, and without smell and taste.

As already stated, reasoning from the habits of plants which are seen on every hand, we might expect an abundant growth to commence in the spring, as it did in this case; but it should continue through the summer months, which we see it did not.

Now, in the Newton reservoir we find a similar growth, but starting about December 12, instead of in the balmy days of spring, increasing astonishingly, reaching its maximum in about 30 days, and then decreasing until the water contains little organic matter in a live state.

Here we see a growth in winter resembling in every way a growth in spring; and, as we examine this chart carefully, we must conclude that the temperature which prevails at different seasons has little influence upon the growth of these minute plants, only as far as it affects the food-supply.

The reason for the large growths in both these reservoirs will be fully explained further on.

The growth in the Boston reservoirs, however, would seem to indicate a somewhat different result, for we see, in June, that the number of organisms begins to increase and continue larger till the weather grows colder; but a careful study of these organisms shows that the warm weather alone is not directly the cause.

The increase in number is not in that class of plants which were present during autumn, winter, and spring, — these, in fact, are less, — but is wholly due to plants of an entirely different family, — the Nostoc, with habits much unlike those just mentioned.

The plants of the Nostoc family derive their food to a certain extent from the decay of organic matter, and are never found in ground waters similar to those of Newton and Brookline. They grow in summer, probably not only because the weather is warmer, but for the reason that, as the temperature of the water rises, the decay of the organic matter present is hastened, and certain chemical changes take place which furnish just the kind of food these plants require; and if this food could be supplied in mid-winter, I have little doubt that this family of plant would flourish then. And I might add here, for reasons just stated, that water which contains a large amount of organic matter, either in the form of mud on the bottom, or sewage matter, may support a large and troublesome growth in summer and very little in winter.

As is well known, the temperature at which different plants can form their protoplasmic food, or in which assimilation is possible, varies greatly. The red snow-plant, for instance, which often spreads over acres of snow in the Arctic regions, grows rapidly in a temperature at about the freezing-point of water. The same is true, as has been shown, with most of the common algæ. The cold weather may retard the time of maximum growth somewhat, but if in a body of water there is a certain amount of food material, the number of organisms will be about the same whether it is winter or summer, and any change which varies the food material changes the organic life to the same extent.

It is not a question of temperature, but food material.

Now, let us look again at the growth which commenced about December 12th in the Newton reservoir, and rose as greatly above its normal state, for the purpose of finding its cause.

This reservoir was drawn off about September 10th, and carefully cleaned. No water was pumped into it for nearly three months, and during this time it was fully exposed to the influence of the sun, wind, rain, and frost; and we should say that if algæ could be killed by drying and freezing, it certainly would have been in this case.

About November 27th, pumping into the reservoir from the filtering galleries commenced. The water from the galleries, in its slow passage through the soil, had taken into solution a large amount of the proper plant food, and, as a consequence, we have a body of water rich in all the elements which are necessary for algæ life, and not yet invaded by it.

We might now compare this body of water to a large pile of very dry wood in which the heat, generated by a single spark, causes the commencement of chemical action which extends through the whole pile, and only ceases when all the wood has been consumed. So in this body of water a single germ and the chemical force of sunshine creates a growth, which increases with marvellous rapidity, till the food material is used up and the plants die of starvation.

This water now is nearly destitute of plant food, and consequently no life is possible until it is again supplied, either by means of fresh water from the galleries, or what it may receive from the gases in the air, and also from the decomposition of the former growths, and not until the reservoir is again drawn entirely off and refilled will the algæ be so abundant. A little later I wish to follow the subsequent growths and point out the changes which occur.

The remarkable growth which commenced in the Brookline reservoir, in April last, was shortly after the reservoir had been emptied and filled with water from the galleries, and the cause for this growth was the same as in the case just mentioned.

And right here I wish to say a few words about the desirability of circulation of water in reservoirs.

In all reservoirs exposed to sunlight which are supplied from ground waters or from rapidly flowing streams, over rocky or sandy beds, circulation is a positive injury. Every gallon of such water contains food for millions of organisms, and each drop pumped into a reservoir increases the amount of organic matter to a corresponding extent.

In proof of this, you have only to look again at the remarkable growths in the Brookline and Newton reservoirs just alluded to. If a building was on fire, and to quench the flames a quantity of very combustible material should be thrown on it, it would not be difficult to foretell the result; and there is no more reason in pumping into a reservoir a quantity of fresh water, with the idea in view of improving the quality of that water in so doing.

As additional proof of the statement I have just made, I will relate a little experience we had in the Brookline reservoirs several years ago. Everybody said that circulation was what we needed to keep the water free from algæ, and one time after the reservoir had been carefully cleaned, this view of the case was given a thorough trial. It was in summer, when our daily consumption was about a million gallons. All the water, nearly, was pumped into one end of the reservoir, and made to pass through it. The amount of water in the reservoir during this trial was not much in excess of the daily consumption; in other words, nearly as much water was pumped into the reservoir each day, and drawn from it, as the reservoir contained, yet the algæ came in about the same length of time, and were fully as abundant. In consequence of this, the consumer received no water which was not laden with algæ; whereas, if the water had been pumped directly into the distribution, and only the surplus reached the reservoir, the water would have been good as long as pumping continued.

It is doubtful whether circulation improves water in any case, unless it is in ponds and reservoirs which have deposits of mud or decaying vegetable matter on the sides and bottoms, or water which has been drawn from such sources.

It may be interesting to say a few words in relation to the way these plants — algæ — are enabled to form their food, wholly or in part from inorganic matter.

By a little thought in this direction we at once see that all organic matter was once inorganic, and also that one kind of plant life is ever changing inorganic matter to organic, whilst another class of plants and animals are changing this organic back to inorganic again.

And it might be stated here, that not one particle of inorganic matter can be changed to organic without the chemical force which sunshine alone gives, and on this one fact hangs the existence of the entire vegetable world, and consequently life of all kinds. But to return; some plants cannot live and grow without the help of a certain amount of organic matter which has been provided by other plants, although they may create their own food to a large extent. Such examples we find in the forest trees, grasses, and all cultivated plants.

Other kinds of plants, however, are able to manufacture all their food from inorganic matter; to this class belong many mosses, all the lichens, and a large part of the algæ. By far the larger part of a plant body is composed of starch, or some of its kindred compounds; but in addition to this there must be a certain amount of iron, nitrogen, sulphur, and potassium, and often other elements.[1] These latter are present in a limited amount usually, but are as necessary as the nails and pins in the construction of a house; in fact, without some of them plant life would be impossible.

Starch, which has just been stated forms the greater part of the plant body, is composed of carbon and water, — largely of the latter. The carbon is derived, probably, mostly from carbon dioxide, which the water receives, to a large extent, from the air; and the iron, sulphur, nitrogen, etc., which ground waters contain in much larger quantities than surface waters, are taken into solution in the slow passage of the water through the soil. Nitrogen, however, may result quite largely from the decomposition of organic matter present in the body of water.

From this it will be seen that, although the iron, sulphur, etc., forms only a very small part of the plant food, yet those waters which contain these in larger quantities will support a much larger growth of plants.

Water which is deeply colored may be nearly destitute of life; in fact, color is

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[1] With the single exception of oxygen, the elementary constituents named above do not enter into the food of plants in an uncombined state; on the contrary, they are always absorbed in the condition of compounds, as water, carbon dioxide, and the

Nitrates,	of	Ammonia,
Sulphates,		Potash,
Carbonates,		Lime,
Phosphates,		Iron,
Silicates, or		Soda, or
Chlorides		Magnesia.

In addition to these, many organic compounds are absorbed in particular cases, as in those plants which live in decaying animal or vegetable matter (saprophytes), as well as those which absorb the juices from living plants (parasites).

no indication of the presence of plant food. The vegetable solutions from which the color is derived may be that part of the former plant body which in itself is incomplete for plant food.

And following in this same line of thought comes the fact, that the more this organic matter which the plants have changed from inorganic is worked over and elaborated, the more complex becomes its structure, and more offensive it is in the process of decay.

Nearly all green plants during stages of decomposition are not troublesome or obnoxious to the sense, but during the decay of animals which feed on these plants, and fungi, even, the opposite is true, as we all very well know.

The plants of the Nosto family, of which the Clathrocystis is widely known, plants which probably obtain part of their food from the breaking up of other plants, are characterized by their unpleasant odors, and are much more disagreeable than the diatoms and plants of similar classes.

Now, I have noticed that the first growth which occurs in the Brookline reservoir after cleaning, and the same is true in the Newton reservoir, is not as noticeable, does not have such a decided and disagreeable taste, as growths which occur later. No one complained of the water in Brookline during the remarkable growth of last April, although a slight fishy smell was present; but in January of this year the water became so offensive, that it was necessary to exclude it from the town, and pump continuously, but by referring to the chart you will see that it was quite small in comparison.

The first growth are usually diatoms, protococcus, or plants of a similar class; plants which can form all their food from inorganic matter. These are continually dying and dropping to the bottom, where, during the process of decay, they furnish food for other plants and various kinds of animal life. These latter impart a far more disagreeable taste to the water. The trouble in Brookline in January, which has just been mentioned, was from infusoria which were feeding on the decomposing algæ.

I wish now to speak about the appearance of certain algæ in certain bodies of water, and also in relation to the danger of seeding one body of water with algæ growths from another. From my studies in this direction I do not think there is any danger of seeding one reservoir with the growth of another; or, in other words, if in a body of water exposed to sunshine the necessary food is present, it is utterly impossible to keep the algæ out; and, furthermore, the growth which is best adapted to live there will appear.

To illustrate this I will cite one case. Two years ago, last summer, the water in the Brookline reservoir was bad, and it was necessary to draw it off, and in so doing some of the water ran into one of the Boston reservoirs, owing to the partial stoppage of the overflow drain; but repeated microscopic examinations failed to discover any of this algæ in this reservoir. After the Brookline reservoir had been cleaned, over 100,000 gallons of water from the Boston reservoir was turned into it; but one month afterwards none of the algæ peculiar to the Boston water was found, and none have since appeared.

The very same plants which increased so enormously in both the Newton and Brookline reservoirs are often present in the Boston reservoirs and many other bodies of water, but only to a limited extent; yet if the food-supply was as abundant here the growth would undoubtedly be as large. The very infusoria

which gave Brookline the trouble in January is often found in Boston water, but not abundant enough to cause notice. And so I might go on for an hour, and point out cases similar to those just mentioned.

The question how they get there is not so easily answered, but a few observations of the possible ways of transportation from one pond to another may be stated. People who have studied the habits of frogs tell us that this harmless animal often travels from one pool or pond to another, making these journeys usually in the night; and from my own observation I know this statement to be correct.

The frog, in common with many reptiles, secretes a sticky fluid which covers his entire body; to this the algæ may adhere, and be carried long distances eventually.

Also the spores of the volvox, which many botanists claim must be dried before germination is possible, can be brought to the surface by the frog after one of his frantic plunges to the bottom, and dried sufficiently to suit the most rigid believer in this drying theory.

All birds frequent ponds, more or less, while some obtain their whole food from such places, flying from one neighborhood to another. In this way it is quite possible those minute plants may be widely scattered.

The thousands of insects which in summer are hovering over wet places may also act quite an important part here. It is quite probable, however, that the spores of these plants are more frequently distributed by the wind than by any other agent, perhaps not to germinate at once where they happen to be finally deposited, but to quietly wait a favorable time for their full development.

You can feel assured that if the food material fit for a certain class of algæ is present, that class of algæ will thrive there, and the only way to prevent this growth, as long as the water is exposed to sunlight, is to cut off the food-supply.

We know that absolutely pure water is incapable of supporting any kind of life. If there was some way of filling our reservoirs with such water, and maintaining this purity, algæ growths would be unknown.

I wish now to speak of the distribution of algæ in a body of water. Investigation in this direction shows that algæ are not usually, or in fact never, uniformly distributed. A sample from the surface or any other level may be wholly misleading as to the number of organisms present in the whole body of water.

To illustrate, I will give the results of a few examinations.

In the Brookline reservoir, July 20, in 50 c. c. of water there were 29,328 asterionella, and on the bottom, 38,916; on Aug. 2, at surface, there were 28,764, about the same number as on July 20; but on the bottom there were 340,938, or more than ten times as many as found here two weeks before.

A sample from Chestnut-Hill reservoir, taken Aug. 10, 1889, in same amount of water, showed at surface, 137,500; Clathrocystis, 12 feet below, 39,340; bottom, 5,076. While in same sample a diatom cyclotella was as follows: at surface, 3,800; 12 feet below surface, 3,384; bottom, 1,270, — much more uniformly distributed.

I might give you many other cases which differ as widely as those just mentioned, and also from other locations, but it hardly seems necessary.

And further, I have noticed that a growth which had been quite evenly dis-

tributed for several days, suddenly went to the bottom, and was found only in a layer about two feet deep. The whole growth was concentrated here, and the number was consequently very large.

In such a case, an average from samples taken at surface half-way down, and on bottom, would give too large results by far. And it is for such reasons as these that the results of several observers may differ largely. Another strange thing in this connection is, that one plant does not often flourish longer than a few weeks at one time. Where we find to-day a certain plant in abundance, a month or six weeks later it has, perhaps, wholly disappeared, and some other one heads the list, but only soon to give way to another; and so the changes are ever going on.

If the algæ in a pond or reservoir are to be studied thoroughly, samples should be taken as often as once a week, — even in this short time changes may occur, — and not less than three in number at different depths; a greater number would be better. A sample taken only at surface is not a true indication, and would lead to wrong conclusions, as has been shown.

After all, it may be said, What is the use of all this study? But it must be borne in mind that before a remedy can be suggested we must know the whole ground thoroughly.

A person cannot do an algebraic sum until he understands the principles of algebra. We do know that the exclusion of all sunlight will prevent the growth of green algæ. We have demonstrated this fully in Brookline.

About five years ago Brookline built a high-service system, and the water for this was stored in an iron tank fifty feet in diameter and thirty feet high.

The same growth appeared here which had caused so much trouble in the L. S reservoir, although no water from the reservoir was pumped into the tank. The frequent change of water, which was unavoidable in a tank of such small capacity, increased the growth, and it was even worse than in the low-service reservoir. Two years ago last August the tank was roofed over, excluding all sunlight, since which time no green algæ has been found, and the water has been free from taste and smell.

There is a class of plants, however, which thrive as well in complete darkness as in sunlight; but such plants are not able to make their own food, and are wholly dependent on food made by other plants.

Water which contains vegetable solutions in sufficient quantities with certain organic matter, might develop a very extensive growth in total darkness.

In the Brookline filtering gallery and high-service tank there is a slight growth of crenothrex, a plant of this kind, but in too small amount to do injury; and it is very doubtful whether waters which contain no more vegetable matter in solution than those furnished by Newton, Waltham, Hyde Park, and Brookline will ever be troubled by plants of this kind.

In closing, bearing in mind what is already known on this subject, a few suggestions might not be out of place.

Where it is necessary to store ground water, it should be in covered reservoirs or tanks, and in planning new works where water is obtained from such sources this feature should receive prominence.

This might lead to smaller reservoirs and larger pumping plants and force-mains. Be this as it may, a good water, and no other, is to be desired.

In construction of storage-basins and reservoirs for surface waters, all vegetable matter should be removed from the bottom and sides. They should also be built so as to allow for cleaning.

The algæ which is constantly falling to the bottom, unless removed, may give rise to subsequent growths of very unpleasant natures.

It is also desirable to arrange the basins and reservoirs so in case of an invasion of one by an organism which may make the water unpleasant, it can be isolated from the others without interfering with the supply.

If this paper, which I have just read, awakens a greater interest in this subject, and turns the attention of those who have the charge of water works more in this direction, it will not be in vain that you have listened so patiently this afternoon to the poor attempt to shed a little light on this partially explored region.

Prof. Drown. — I have listened with a great deal of pleasure to Mr. Forbes' paper. It seems to me that he has done an admirable piece of work in investigating a limited number of supplies with very great care, and comparing them with one another. The subject that most interests me, personally, is the relation between the growth of these organisms and their food. I remember hearing Mr. Forbes speak on another occasion with regard to the Brookline reservoir, when he gave more in detail than he has this afternoon the connection between the exhaustion of the food and the death, or the disappearance, of the organisms. I have had a similar experience in the water of the Hyde Park reservoir, which was experimentally shut off from the distributing system, in two divisions; that is to say, the water in the reservoir was exposed to the light, and that in the gate-house was kept secluded from the light, with the same water. The growth of algæ in the reservoir was very abundant at the start, but in a short time, within two or three weeks, they disappeared entirely, which agrees perfectly with Mr. Forbes' observations. In the gate-house, where there was no light, the growth never appeared to any noticeable extent, certainly not to an extent to give any annoyance. The chemical results at that time were very interesting. Mr. Forbes has alluded to the food that the plants derive from the ground waters, which, in the language of the chemist, is the nitrogen, in the form of nitrates. As many of you know, nitrogen we determine in four forms, — organic nitrogen, nitrogen as free ammonia, nitrogen as nitrites and nitrates; and the nitrates are generally abundant in these ground waters. The water at Hyde Park coming from the wells is moderately high in nitrates. As the algæ increased the nitrates decreased, and when the growth ceased or disappeared, that is, either sunk to the bottom or decomposed, the nitrates had disappeared also, entirely, coinciding with the observations of Mr. Forbes.

The diatoms are generally the most abundant forms in those waters which are high in nitrates, as in ground waters, which are exposed to air and light in reservoirs. In the Ludlow reservoir, of Springfield, we have entirely different conditions. It is surface water there, entirely free from any sewage pollution, or anything of that kind; but the region is a swampy one, and the reservoir has a muddy bottom. Here we do not find the diatoms abundantly, but rather algæ belonging to the Nostoc family; an occurrence which forms an interesting confirmation of Mr. Forbes' statement.

Mr. ALLIS. — I notice that most of Mr. Forbes' remarks with regard to the effect on the growth of algæ of covering the water were made in connection with ground waters. I would like to ask him if he believes water taken from an open pond like Spot Pond would be affected favorably in the same way.

Mr. FORBES. — I do not think it would. You would be pumping water from your pond into a covered reservoir or covered tank. That water going into this covered reservoir or tank would contain a certain amount of green algæ, and that algæ, when placed in a covered reservoir, would die. The decomposition of this algæ might make the water more offensive than when the algæ were in the live state. If you are continually pumping from a pond which is full of algæ into a covered reservoir or tank, they will be continually dying in there, and the covering would probably, instead of improving the water, make it worse.

Mr. ALLIS. — Some time ago we had a great deal of trouble in Spot Pond on account of a fishy taste. I would like to ask if algæ is found most frequently, or is especially bad, in those ponds where grass is pulled up by the ice in winter, and allowed to decompose on the bottom of the pond? At the time to which I refer we had a great deal of trouble with the water. It smelt very bad, and it tasted very bad. We were pumping the water then from the pond into a gate-house, and by raising the delivery-pipe about 12 feet and allowing it to come down through some screens, you could smell the water a good ways off, but it really made it very much better; therefore it occurred to me that possibly the trouble with us was more from the action of the gaseous compounds of the decomposing grass in the bottom of the pond. I don't know but what I was mistaken, however, and that it was the algæ, after all. You remember Mr. Ball's remarks at the meeting at Manchester, when he told us about taking the water from different heights of the pond, — in the winter taking it from the bottom, and in the summer taking it from the top. We have tried that at Spot Pond, also, and we think it makes some difference. We certainly have had no such trouble in Spot Pond as we had two summers ago. I think, perhaps, one reason is that we have had an abundant supply. The pond has been overflowing, and the little place where the trouble occurred has been covered deeper. I would like to know if this trouble in the water is always due to the algæ, or is it, in some cases, when the pond is in a bad condition, due to the gaseous compounds of decomposition?

Mr. FORBES. — Of course algæ are plants just the same as grass or anything else, and when any kind of vegetable matter is decaying it may impart an unpleasant taste to the water. The trouble the gentleman speaks of might be owing to the algæ, it might be owing to the animal life that was feeding upon the decomposing vegetable matter, or it might come from the grass, or whatever there was in the reservoir. It would be impossible to tell, without an examination at that time. But, as I say, algæ is nothing but a plant, of course, and that, the same as grass or anything else, might impart the taste to the water.

Mr. HAWES. — There are plants that grow in water that are not considered injurious, like the water-cress, — that is a very nice thing to eat, and it grows entirely in the water; and there are other vegetables which are nearly all water, like the turnip, which is 95 per cent. water. But is this vegetable matter that grows in the water, these algæ, injurious to the human system? If it is not, what is the use of trying to get it out, and covering the water over, and all that sort of thing, to prevent its growth? I would like to know whether it has been

chemically analyzed so anybody can tell whether it is injurious to the human system or not.

Professor DROWN. — Perhaps it may comfort Mr. Hawes a little to know that the amount of solid organic matter in a surface water which is fairly turbid with suspended plants is excessively minute. In the water of the Ludlow reservoir, which I have already mentioned, there is frequently an excessive growth of blue-green algæ, so that one would naturally suppose that the water contained a large amount of solid substance. But when this green mass is thoroughly dried, the amount is less than one grain of solid, dry vegetable matter to the gallon. I can't say whether, if taken in large quantities, it might have any appreciable effect, but the dose is so minute I can't think, even if it were a strong poison, it would do any particular harm.

Mr. HAWES. — I don't think any one of us will drink enough water to get many grains. (Laughter.)

The PRESIDENT. — During the past summer, there was reported to me a case of a tank which was filled with a gelatinous substance so full that the outlet was closed, and the tank overflowed. I submitted some of this substance to Professor Sedgwick, and I will now ask him to give us the result of his examination.

Professor SEDGWICK. — I hesitate very much to depart at all from the line of discussion opened up by Mr. Hawes, and more especially by Mr. Forbes. It has been very interesting to me, and with your permission I should like to say a few words upon that subject, before I take up the matter which you have suggested, in answer to the question, "Are these things of any harm, or are we really only getting more for our money, so to speak, when we have water which is full of vegetable matter?" That is a legitimate question, because many of these things are good to look at and not bad to eat. But, on the other hand, there is this to be said, that organisms which are good under some circumstances, every now and then give up the ghost, and when they decay other things come in that may, though we cannot say that they always do, produce serious distempers. Whether the grippe had its origin in one of these or not it is very difficult to say, but its origin probably had nothing to do with anything so harmless as water. The grippe began, you know, with the Czar of Russia, and he fights with dynamite, not with water.

The organisms which come in and do the harm are, of course, the germs of disease, if they do come in, and if they do any harm. But I cannot help feeling that the whole question of algæ in water is, after all, a good illustration of the fact that we in this country advance rather by working out our own experience than by accepting the experience of others, or what we might call "recorded" experience. Some one has pointed out that that is the American way of doing things; that we do not want to take any information from any other country, or from anybody else, but that we want to work it all out for ourselves. That is very admirable and very helpful in many cases, and we do accomplish good results in that way. But before the city of Zürich, for example, is supplied with water it goes to work and gets these organisms out. You cannot stop them from growing — (Mr. Forbes, I think, is quite right; they grow independently of many of the ordinary conditions which we are apt to supply to them) — but after that, what are you, as engineers, going to do about them? Are you going to continue to supply water containing such things as these, or are you going to do as

cities in Europe have done, a good many of them, already; that is, filter these things out, and deliver water free from them? That is a question, of course, for each water-works superintendent to answer for himself. But I would like to say this, that at the Lawrence experiment station, which the State Board of Health is carrying on in this State, some tanks have been running for about two years filtering the water of the Merrimac river at the rate of several hundred thousand gallons a day, some of the time as high as a million gallons per day, per acre, and every one of these algæ, every one of these animals, has been removed. Moreover, the bacteria, which may possibly produce colds, and the grippe, and diseases of one kind or another, — may possibly, I say, we don't know that those in water do; but which are things to be gotten rid of, and which Berlin and Zürich, and other places, are getting rid of, — have often been reduced from perhaps an average of 100 in the Merrimac river to an average of perhaps five or ten per cubic centimeter, by this simple plan of sand filtration. Now, it seems to me that after investigating this subject, and learning all we can about algæ, we have got to go farther, and get rid of them; and I leave that idea with you, as something to be thought over. Is it not time for our American cities to have as good water as the city of Zürich, which has not nearly the wealth of the city of Boston, I suppose, or as good as the water supplied to the city of Berlin?

To return to what Mr. Brackett asked me to speak of, I have here a sample of the jelly he sent to me, and which, I suppose, he will hardly recognize at this time, as it is now in glycerine, for preservation. I want to say a few words about it, for this reason: it turned out to be a very interesting thing. It was found in a water-closet tank which it had filled so full that the tank could not be used. It was simply a mass of jelly of a greenish color, and at first sight it would, perhaps, suggest to anybody the Nostocs, or some other blue-green algal jellies. If I hadn't happened to have had a little experience with it before, I should have been puzzled by it, because I had never but once before seen anything like it. There is a lake near Boston upon which there grows in the spring a scum of jelly, sometimes in spots, several inches thick; great patches of this go floating around the pond, and it is a nuisance. My attention was first called to it two years ago, and on examining it I supposed I should find some of the ordinary blue-green algal jelly such as one sees sometimes in the summer in lakes and reservoirs. On the contrary, it turned out to be nothing of the sort. It was, in fact, a jelly stage of bacteria. That is the first case I ever saw on a large scale, and since, so far as I know, it is altogether new, I want to ask the members of this Association, — to which, this day, I have been very kindly admitted, and for which I wish to return my thanks, — I want to ask them if they meet with any cases of remarkable accumulation of jelly which they do not know how to account for, to do up a bottle of it and send it to me at the Institute of Technology. We have had, first, the case in a lake in Wellesley; second, the case which Mr. Brackett referred to us, in which the jelly had grown in a water-closet flushing tank; and third, since that time, — for it is curious how, when you meet with a thing, other examples of it appear, — in a case in Lawrence. A resident there has a tank in the top of his house, from which the house is supplied with water. This tank was so full of the jelly that the water would not run out. There was nothing bad about it, but it was a nuisance.

In all these cases we have the jelly stage of certain bacteria. I dare say it occurs rather commonly, but it has not been brought to the notice of biologists, so far as I know, and I should be very glad to get other specimens of it, because it is quite an interesting phase in the life history of these organisms. The practical bearing of it I take to be simply this: that in the right stage and under the right conditions the bacteria become altered. Their cells become partly mucilaginous, and thus produce a jelly, which, of course, if it once got into a city supply, might choke up all the ordinary service-pipes, and would be a great nuisance. It is fortunate that it is scarce; but I would like to repeat what I have said, if any one meets with a case of this kind of jelly, especially if growing in the dark, and having either no color at all or a faint greenish color, I should be very much obliged if he would send me a fruit-jar full of it.

The PRESIDENT. — Professor Drown has a few remarks to make, which he wishes to make now while the subject is fresh.

Professor DROWN. — I have a specimen here which was handed to me by Mr. Noyes a month or two ago, and I am afraid it will go to pieces if I try to keep it for a month longer. Perhaps this communication might be made more appropriately by Mr. Noyes than by me; certainly it is his by the right of discovery. It looks something like a sponge or piece of dried moss. I think he told me it came from the interior of one of his large mains, — on the upper side, if I remember rightly. Our microscopical expert pronounced it to be the spongy remains of bryozoa, an animal which secretes mineral matter from the water in which it lives, and makes for itself a sheath as the coral polyps do; the earthy matter of this sheath remains after the animal has died. I thought it would be interesting to determine what was the chemical composition of this mass, since the mineral matter in it must have come from the water. When Mr. Noyes brought it to me, it was moist and had a very pleasant, mossy odor. Now that it is dry it has no odor. The organic matter in the mass is only about 18 per cent. The residue contains about 39 per cent. of silica, about 23 per cent. of oxide of iron, and 3 per cent. lime. And what is very remarkable, it seems to me it contains, in addition, 33 per cent. of oxide manganese, a substance which we did not know was present in the Newton water. Perhaps on concentrating a large quantity of the water by evaporation we may be able to detect the presence of manganese. The animal could not get the manganese from any other source than the water, except, perhaps, from the iron pipe to which it was attached. But this latter suggestion seems to me very improbable. I anticipate Mr. Hawes' question as to the possible injurious effect of manganese on the system by referring him to Mr. Noyes, who can tell him about the health of the people of Newton.

Mr. NOYES. — My attention was first called to the presence of this growth in the water-pipes when cutting out a section of 16-inch and 24-inch force main in order to make other connections. The coating was apparently as thick as the specimen when it was moist, from three-eighths to half an inch; it was thickest on the top, gradually became thinner on the sides, and on the bottom there was very little. Not having known of it before, and having occasion to again break out the main, I took this sample from the 24-inch pipe and gave it to Professor Drown. The conditions are, the force main is near the pumping-station, and is subjected to a constant water pressure of about 80 to 87 pounds. I also found imbedded sev-

eral small mollusks about one-fourth inch in diameter, of about the same shape as a quahaug or a little neck clam, and these were apparently alive.

It interested as well as puzzled me to know how this class of life could be sustained under such conditions. I supposed it must be peculiar to our supply, which is, as you are probably aware, ground water, until I observed the same growth and shell-fish in a cast-iron special which had been taken from one of the water mains of the city of Somerville, which is supplied with water from the Mystic Division of the Boston Water Works, and is a surface water-supply.

Shortly afterwards, when putting in the foundations for a bridge over the Charles river, they dug out a large rock that had been imbedded on the bottom, and on the portion of that rock which was above the bottom of the river-bed I found a mossy growth somewhat similar in fibre to this, and I found imbedded in it this same mollusk, which led me to conclude it could not be due entirely to the conditions of excessive pressure, because in this case it was but two or three feet below the surface of the water. Of course Professor Sedgwick or Professor Drown can explain fully that which seemed to me very singular at the time.

The PRESIDENT. — As this seems to be a question of clams, I don't see but we shall have to refer it back to Mr. Hawes, who I think is authority on that subject. (Laughter.)

Mr. NOYES. — As Mr. Hawes does not rise, perhaps I can say a word or two which may throw some light on some facts which Mr. Forbes has stated. I don't know but what all the members may be fully aware of the conditions, but in looking at the diagram which Mr. Forbes exhibits for the months of October, November, and December, it would appear as though this growth in the Newton water was very slight. I presume from Mr. Forbes' explanation that these samples were taken from the reservoir, but the Newton reservoir at that time was empty, and we were pumping directly into the pipes. Now, while Newton water is ground water, yet it is exposed to the light and sun in a filter gallery, which is nothing more than an elongated well. During these months we were pumping directly into the pipes day and night, and yet there has been no time during the existence of the works when there has been so much complaint of the odor and taste of the water as there was at that time.

Since filling the reservoir the annoyance has not been so great, although there have been complaints from time to time of the odor from the water. I merely make the explanation because I see that the growth is somewhat high on Mr. Forbes' diagram for Brookline, and would appear to be low for Newton.

Touching on another point, I think Professor Sedgwick referred to the effect of a dry season. I recall that the first real serious trouble we ever had with the Newton water was after a dry season; I think it was in 1883 or 1884, when for several months we were pumping continuously from the filter gallery, and the level of the water in the filter gallery during this period was maintained very low. During those months the growth in the gallery was considerable, and the men were continually employed in cleaning it out. The drought continued until late in the fall, and the water in the gallery did not rise to its normal height until well into the winter, when the high water in the river held back the ground-water, so that it was unusually nigh in the spring, when we began to have serious complaints of the unusual odor from and taste of the water; and the explanation

seemed to me at that time to be, in cleaning out the growth in the basin it had been thrown upon, and had become partially incorporated in, the sand of the banks in the shape of a fine powder which the water had taken up. This is only an idea suggested to me without any intelligent foundation for it.

I recall one or two cases where we have found growths of a jelly-like substance in tanks. As spoken of by Professor Sedgwick and our President, I supposed it to be due more to lack of cleanliness on the part of the householder than to anything else. I believe the tank was cleaned out, but the same jelly-like substance reappeared again. I have also found these jelly-like clusters in the filter gallery, but I do not know whether they have any relation to what Professor Sedgwick has in mind. The next time it occurs I shall be pleased to send him a sample.

Professor SEDGWICK. — I think that perhaps I ought to say that there are many jellies such as Mr. Rafter has spoken of. We are all familiar with the Nostoc jellies, etc., and I daresay Mr. Noyes' jellies in the filtering-gallery were of that kind. They probably were not bacterial jellies such as I have described, because the bacteria in that gallery have not been very abundant. But Mr. Noyes has brought out what I was going to ask Mr. Forbes if he had noticed, and that is this, namely, the condition of the Newton water during October, November, and December, when the chart shows, of course, nothing in the reservoir, because it was empty. At that time the smell of the Newton water being bad, one of my students, who lives there, brought me some of it. As I had frequently seen the Newton water before, I examined it again with interest, and to my surprise found it almost a pure culture of Asterionella, the very diatom which has been discussed. I sent out to the filter-gallery for a sample, and found the filter-gallery water also full of Asterionella. It seems to me to confirm Mr. Forbes' idea, that the temperature was not the main factor, because the filter-gallery is pretty constant in temperature, and yet in the summer this diatom was not there, while in the fall it was in great abundance. During the summer there are filamentous algæ, green slimes, and pond scums present in the filter-gallery to a limited extent, and I believe they are raked out from time to time. My idea of it is that in the fall these died, and afterwards furnished food to an extraordinary number of diatoms, which then took their place in the filter-gallery, and of course were distributed to the city.

METHOD OF CLEANING THE DISTRIBUTING RESERVOIR OF THE NEW BEDFORD WATER WORKS.

BY

R. C. P. COGGESHALL, Superintendent New Bedford Water Works.

Read March 12, 1890.

The distributing reservoir of the New Bedford Water Works has a surface form of a trapezium and covers an area of about five acres. The earthen embankments which compose its sides are fifteen feet in width at the top, with slopes inside and outside of two feet horizontal to one vertical. The general dimen-

sions through the middle are about 345 feet by 255 feet. The bottom is the natural surface left after excavation, and is gravel well filled with clay. The vertical height from the bottom to the level of the top of the embankment is 20 feet. A depth of 18 feet constitutes a full reservoir, and that volume contains 14,957,101 gallons.

During the month of April, 1888, this reservoir was drained for the purpose of making extensive repairs to the well of the gate-house, and also to the stone facing on the inside slope walls. While these repairs were in progress, the side walls and bottom were thoroughly cleaned. It is now my purpose to briefly describe the manner in which this work was done.

At a convenient location on the south inside slope, a runway four feet in width was placed. Two-inch planking was used, and a ledge fastened to the sides to prevent the truck from slipping off. At the top of the slope this runway connected with a level plank platform, extending across the top of the embankment and continued to a convenient distance beyond the foot of the outside slope. Near the end of the platform and well beyond the outside slope was a hole of convenient size, through which *débris* was dumped some fifteen feet to the ground beneath.

The runway on the inside slope allowed the use of a truck 2½ feet by 5½ feet, constructed of 2-inch planks, having three cross-pieces underneath 2 inches by 6 inches, and two cross-pieces on top 2 inches by 6 inches placed edgeways, — one on the lower edge of the truck, the other in the middle. This allowed the placing of two tubs upon the truck at the same time for haulage up the slope without danger of either slipping. The truck ran on six large casters, having 4-inch wheels.

The haulage was made by means of a single rope spooling over a 4-inch derrick wench without gearing. This wench had a crank on each end and required two men to operate. A third man manipulated the slack of the rope. By this method the truck was operated with ease, and more rapidly than it could be done in any other way.

Six tubs were used. These were made from 50-gallon oil casks cut in two. For convenience in lifting, handles were placed on opposite sides.

In eight days from the time the reservoir was discontinued from the distributing system the bottom was in condition for cleaning. Nearly all moisture had then evaporated from the material to be removed. A vegetable deposit, averaging from a quarter to a half an inch covered the bottom. At the foot of the slope walls, especially in the corners, there was found a large quantity of gravel which had become displaced from beneath the stone lining of the slope by reason of the continued wash of years upon it.

All the material to be removed was thoroughly scraped into convenient piles and then transferred to the foot of the runway by means of wheelbarrows. Here it was placed in the tubs, they being upon the truck. The truck was then hauled to the top of the slope and run along the platform to the hole near its end. The material was then dumped, and the truck, together with the tubs, quickly returned to the bottom of the slope. The dump heap thus formed beneath the platform was afterwards removed by carts.

Mr. Noyes. — I would like to ask Mr. Coggeshall how long a time the deposit he speaks of had been accumulating.

Mr. Coggeshall. — Twenty years.

Mr. Fuller. — I should like to ask Mr. Coggeshall if the running down of the gravel from under the paving of the reservoir did not allow the paving to settle out of place.

Mr. Coggeshall. — Yes; some eight years or more ago the wall had become pretty thoroughly demoralized, and we then lowered the reservoir so that there was only about 4 feet of water left in it, and repaired it at the time, thoroughly grouting the joints, so that the face of the wall now is in very good condition.

The President. — I hope if any of the members have had any experience in cleaning their reservoirs, they will give us the benefit of it. I think the city of Newton has lately cleaned its reservoir, and perhaps Mr. Hyde will give us some information as to how the work was done there.

Mr. Hyde. — Our reservoir was cleaned last fall, and in a similar way to that which Mr. Coggeshall speaks of, with the exception of the wheels, buckets, and derrick. We had rather more of an accumulation of vegetable matter in the bottom of the reservoir, I should think, than he had. And when our reservoir was cleaned, we also had occasion to put in two check valves in the gate-house, which were in rather a bad condition.

EXPERIENCE WITH A THIRTY-INCH GATE.

BY

Hiram S. Nevons, Superintendent, Cambridge. Read March 12, 1890.

Mr. President, — As this is an experience meeting, I will relate mine with a 30-inch gate, located within 150 feet of the fountain at Fresh Pond and on the Stony Brook pipe line.

This gate controls the inflow from Stony Brook through the fountain into Fresh Pond.

From the first use of this gate some three years ago, it was found that as soon as the gate was opened far enough for the water to commence flowing, a surging motion commenced with such force as to hold the gate rigid for half a minute, then it would relax and become quiet, and one man could easily turn the gate, perhaps one turn, when the surging would again commence with greater force, and it would be almost impossible for two men to move the gate until it became quieted.

This would continue until the gate was open about 6 inches.

Great care was taken in opening the gate slowly, but nothing that suggested itself seemed to help the condition of things. The shock was so great that within one year ten joints were started within 1,000 feet of the gate, and it became a source of dread when it became necessary to manipulate this gate.

From the first observation of this trouble it was supposed to be air in the pipe, and great care was taken in going to all of the air valves and opening them; but no indication of air was observed. This was repeatedly done.

Still, theory, and every one who was asked in regard to it, would reply, "There is air in the pipe."

Thinking that perhaps the trouble might arise from other causes, and not presuming to say that theory and experienced men were *wrong*, yet, thinking it caused by the receding and returning of the water as the gate was opened or shut, an 8-inch by-pass was placed around the 30-inch gate, and now when the flow is started or shutting off is done with this 8-inch gate, no trouble from a surging motion is experienced, and the gate is manipulated with great ease with one hand. Every one connected with the intake of Stony Brook supply is happy, as far as manipulating the gates is concerned.

Referring to the *blue-print* the City Engineer has kindly furnished me, of which I have a few copies and will pass them around, you will see that the distance from Stony Brook dam to Fresh Pond is about 7½ miles.

The *elevation* of Stony Brook is 81.—, and at Fresh Pond 16.85, making a head of 64.15.

You will observe that near Fresh Pond, *sections* marked "Dexter avenue" and "Holworthy street," the grade rises very quickly. It was supposed when this pipe was laid it would act as a *siphon*, but on opening the gate at Fresh Pond the water would rise about 6 or 8 feet from the pipe, and remain so 3 or 4 minutes, when it would rapidly fall away.

It was found that, with all the care that could be exercised in opening, the flow *would* break at "Holworthy street" and "Dexter avenue." Having occasion to open the 30-inch gate a few days ago, the 8-inch gate was first opened, then when the 30-inch was opened about 3 or 4 inches the 8-inch was shut, while the 30-inch was being slowly opened. The result was a steady flow without any perceptible change, except a steady increase in the flow until the gate was wide open, and so remained.

The PRESIDENT. — I will now call upon Mr. Holden, of Nashua.

INEQUALITIES IN WATER RATES.

BY

HORACE G. HOLDEN. Read March 12, 1890.

Mr. HOLDEN. — Having lately received communications from different parties in relation to water-rates, stating that they were about revising their rates, and asking for an exchange of mine, I have written a short article on that subject which, perhaps, may be interesting.

After a water department has been in successful operation long enough to reach that point where the income derived is sufficient after paying the interest on the debt, together with the annual cost of maintenance and yearly construction, and still have a balance on hand for a sinking-fund, then a reduction of the water-rates is usually in order. Now, having lately had occasion to revise our tariff of water-rates, together with the changing of some of our rules and regulations, I was surprised to find, in looking over a large number of rates from different cities and towns throughout the country, that, as far as I could discover, no two places had rates alike, and but very few had even the same rules and regulations. There was, especially, a great diversity in the manner of making charges for family rates, and while many based their charges on the number of

persons, others had a specific charge for each family, irrespective of the membership; others graded their charges by the number of faucets; some by the assessed valuations of the property, and others by the number of feet of frontage; while quite a number of places based the family rate by the number of rooms in the house. I did not find a great diversity in the charges for shops and stores; and in most places the metered rates were well proportioned to the specific charges. Still, I noticed that the rates in the very large cities were much more simple and concise than they were in many of the small towns. As an illustration of the way in which some small towns get up an elaborate tariff of water-rates, I will relate an instance that came under my own observation. Before a company has secured a franchise to construct and operate a system of water works for a town, it is customary for the town council to establish a tariff of water-rates, in order that the company may not be extortionate in their charges to the consumers. Now, I was once interested in some works that were about being put into a village which was the centre of a large farming district located in one of the prohibition States in the West. I have with me the tariff of rates which were established by the town council for this place. It fills five closely printed pages, and comprises almost every use to which water could be placed, even in our largest cities. I will read for your benefit a few of the charges.

There are some 150 or more different charges for a small town; they are arranged alphabetically, and I will only read a few of them. It starts off with alcohol, 10 cents a barrel (laughter); ale-houses, $12.50 to $45; bakers, each barrel of flour used daily, $5; bar-room, $12.50 to $45; barber-shop, first chair, $5, each additional chair, $2; private baths, cold, each tub, $4; bath, private, hot, each tub, $5; baths, hotel and boarding-house, $8, cold; bath, hotel and boarding-house, hot, $10; public baths, $12; brewery, each barrel brewed, 5 cents (laughter); boarding-houses are 45 per cent. more than private residences; brick-yards, churches, candle factories, cigar factories, coffee saloons, are $12.50 to $45; a confectionery saloon is $15 to $100; then there is concrete per cubic yard; and so it runs on, distillery, dyeing and scouring, down to rectifying; and then it comes to residences, and there the charge is by the rooms. For a residence of one room it is $4.50; of five rooms, $5.25; for a residence of 11 rooms it is $13, and each additional room is 95 cents. (Laughter.) Restaurants are $15 to $100; saloons, $12.50 to $45; slaughter-houses, soap factories, powder factories, tobacco factories, vehicles, vinegar factories, washing bottles, and finally winds up with a wine cellar, which is $15. (Laughter.)

Now, as I previously remarked, this town was situated in a prohibition State, where the prohibitory law was enforced, and there was not in the town, and probably never will be, either a bar-room, brewery, or distillery; neither was it probable that there would ever be any kind of manufacturing ever carried on in the place. So that the only revenue from which the company could expect to ever derive much income from, besides the hydrant rental, was the family rates. I suggested to the town council that these charges would be more appropriate if the town was only situated in the State of Kentucky; but I do not believe that our friend Rogers here would consider them suitable for even his State of Maine water works. I afterwards made a compromise with the town council by which they allowed the water company to charge $10 for each family, irrespective of size; $5 for a hose, $5 for a closet, and $5 for a store. And if at any time water

should ever be wanted for any other purposes, and a satisfactory agreement could not be made between the company and the consumer, the company could have the privilege of setting a meter, and receive thirty cents per thousand gallons for the water used; and this agreement has ever since proved perfectly satisfactory to both parties.

Now, I will take another illustration nearer home. The Lowell Water Board, in their seventeenth annual report, just published, have prepared a table giving the charges of 33 cities for water for a family having all the modern conveniences; viz., family rate, water-closet, bath-tub, set-basin, set-tubs, horse, cow, hose. No two of these 33 cities have their individual charges alike.

I have the table here which will show the difference in the rates right here in New England. New Bedford has the lowest, according to this table, $16.25, against Cambridge, $41 for the same fixtures. New Bedford and Cambridge (referring to Mr. Coggeshall and Mr. Nevons) are here together, and they can speak for themselves.

Mr. Nevons. — We have no such rate.

Mr. Holden. — It is so, according to this table, which has just been published.

Mr. Nevons. — That table is not correct.

Mr. Coggeshall. — It is only $13.50 in New Bedford.

Mr. Holden. — It gives here in this table the rates for 33 different places. For instance, here is Concord, N.H., and Fitchburg, Mass., which have a population of about the same; they both have an unlimited supply by gravity, and the rates of Concord are $19, and the rates of Fitchburg are $34 for the same fixtures, according to this table. Take three other places, Cleveland, Buffalo, and Chicago; those three have an unlimited supply, and draw from the same source, as you might say; that is, they draw from the Lakes. The rate of the city of Cleveland for these fixtures would be $21.50, while Buffalo's would be $44.50, and Chicago's would be $42.25. Take the rates now in Lowell and Lawrence; they have an unlimited supply, and they draw from the same source. Their rates are alike, $23, though their charges are entirely different, the total charges, however, amounting to the same. So I find the charges varying all the way from $16.25 up to — I think that the highest is Portland, Me., where they have an unlimited supply, which comes right in by gravity, and there the charge is $42.

Now, I have no doubt but what many new places labor under great disadvantages in establishing their first tariff of water-rates, and I wish now to offer a suggestion that this Association take the matter into consideration of recommending a form of rates by which any new works, or even any old works who are about revising their rates, can get some good practical ideas.

Mr. Winslow. — I would like to ask Mr. Holden if these rates he mentions are the limit for a family. For instance, a person has a house, and puts in his fixtures, where they have a rate of six or eight dollars a faucet; can he put in all the fixtures he sees fit and not have the rate exceed the $23 or $25 — is that the limit?

Mr. Holden. — I take this out of the report of the Lowell Water Board, which has just been published. It is a table to show that their rates in Lowell are about as low as the average. There is a family rate, water-closets, bath-tubs, set-basins, set-tubs, horse and carriage, with use of hose, cow and garden

hose. These are the total rates, I suppose, according to the tariff of rates that they have got from different cities; that is what it would amount to for an ordinary family with those fixtures.

Mr. WINSLOW. — I don't think you quite get my idea. That is what it would amount to under those conditions; but supposing a man were to put in more fixtures, would the rate be increased over and above that?

Mr. HOLDEN. — The probability is that it would be; I don't know anything about it, however. This is as I get it from this report.

Mr. WINSLOW. — The reason I spoke of this was, in some towns and cities where they make a rate of $25, they allow parties to put in as many more fixtures as they see fit, if the house is only used by one family, and it will not exceed that price.

Mr. HOLDEN. — That is the way it is done in most places, I think. Twenty dollars is our limit in Nashua. They can put in as many fixtures as they wish; we make no extra charge for second closets, for instance, and make no charge for bath-tubs, and no charge for set-basins, no charge for set wash-tubs. Many cities make no charge for set wash-tubs; I should think half of them do not, while others do. Some charge $2, some charge $3, and some charge $1, and I see some of them charge $2.50. And for the regular family rate, which is simply, I suppose, for one faucet in a house, the charges are all the way from $5 to $20. The city of Buffalo charges $20, Albany charges $18, Brooklyn charges $16, Portland charges $10, Yonkers, $10; most of the others charge on an average about $5 or $6; Salem is the lowest, $3.50, but it makes up on other things, so the total is $25.

Mr. ALLIS. — I would like to ask Mr. Holden if he really means they charge as high as $20 for one faucet. Did I understand that correctly?

Mr. HOLDEN. — As I read it here that is what it says in this table.

Mr. ALLIS. — For one faucet $20! I would like to be a member of that company. (Laughter.)

Mr. HOLDEN. — The family rate for the city of Buffalo is $20, for the city of Chicago it is $19. All I know about it is what I read in this table. This is supposed to be authentic.

Mr. HAWES. — It is a little curious to look these things over, when we know how tables are sometimes made up. Just look at this now. For the luxuries of life, like a bakeshop, they charge $5 a barrel, while for the necessities, like a brewery, they charge five cents a barrel. (Laughter.) And, then, Mr. Holden goes on and tells us there is no brewery in the place. Now, if that isn't an inducement for breweries to go there, I don't know what is. (Laughter.) We had a case in our town which was somewhat interesting. We charged $2 for every cow that a man kept. There was a man in the lower portion of the town who had three or four cows, and the city put one of these low drinking-fountains right in the street in front of his house, at the junction of another street, and it wasn't but a little while before the man had twenty cows, and he watered them all at this stone fountain. (Laughter.) It made a very dirty place there, and people complained, so when a short time after we had an order to put in a fountain half a mile below there, we decided we would remove this one to that place, and put in the place of the old one, one of these high tank fountains, where you can water your horse without unhooking the check-

rein, but you can't water your cows unless you put up a staging for them. (Laughter.) The man saw what we were doing, and he came out and made a terrible fuss about it; but Mr. Kieran went on and hurried up the job. The man threatened to turn the whole Water Board out the next year, but Mr. Kieran kept right on just the same. (Laughter.) It is astonishing how the quality of the milk has improved since we made the change. (Laughter.) But the milkman was so mad that he died in less than three months (laughter), and the business was sold out.

Mr. RICHARDS. — I think this table will bear correcting in a good many particulars. I find that New London is $2 too high, according to this list; if the correct figures were given it would be the lowest one on the list. There is a mistake of $10 in Cambridge, and New Bedford is $2.75 too high. Judging from these cases I think that table will bear revision.

Mr. STEBEN. — We have experienced a great deal of trouble with regard to our water-rates. Our system is to charge according to the number of rooms and the number of inmates in the house. For instance, for a house of seven rooms, with seven in the family, the rate would be $14; we merely add the number of rooms and the number of the family together. In some cases it is all right enough, but you take, for instance, a man who is getting about $1 a day, and has two or three children, he would be paying as much as a man who was getting a good income, and of course he can't very well afford to pay it. I have placed this matter before our directors very often, but unfortunately they cannot see their way through; they don't know how to regulate it; and I thought I would ask some of you gentlemen what system you think would be proper, and what you think about this system of charging according to the rooms and the inmates in the house. The population of our town is about 9,500. We have 497 consumers, I think. I might add also that we supply the Grand Trunk Railway, and of course the corporation. We get $50 each for the hydrants, and we have 84 hydrants now, so they pay us $4,200 a year, and the Grand Trunk $2,050. We have a total revenue of about $16,000, and the running expenses are about $5,000. We think we are pumping a great deal too much water for the number of consumers we have. During the last month we have pumped 25,875,000 gallons, that is a daily average of a little over 870,000 gallons a day of 24 hours, with a consumption of 42½ tons of coal, making a daily average of 2,500 pounds.

Mr. HAWES. — How much is the consumption *per capita?* Have you figured that out.

Mr. STEBEN. — I don't know the consumption. I believe there is a great deal of waste water, and that is what we want to ascertain at the present time. I might also state that they have put in a system of sewerage there which we have had a great deal of trouble about. The company and the town people are in dispute about it. They started the sewerage system last July, and they claim that we are obliged to supply them with water free of charge for flushing purposes. Of course we refused to supply it, and they went on and attached their hose to the hydrants, and got all the water to flush their drains. We found they were taking some days from thirty to forty thousand gallons which they were using in that way. We think it is wrong that any one should try to cheat the company in this way.

Mr. HAWES. — Do you use the meter system?

Mr. STEBEN. — Unfortunately, no. We have only three meters at the present time, which I have put in, I may say, against the wish of the company. Some of our directors are willing to invest in meters, but some are not, thinking they won't gain anything by it. I have found by the use of one meter that a man who has been paying only $30 a year, has been using water at the rate of $125 a year.

Mr. HAWES. — Make your consumers pay for your meters, and they won't waste nearly so much water.

Mr. STEBEN. — It would be a saving in fuel also. I would like very much to hear from you gentlemen on this subject.

Mr. ANDREWS. — How many thousand gallons of water do you use a day?

Mr. STEBEN. — A little over 870,000 gallons a day.

The PRESIDENT. — You have about 500 consumers?

Mr. STEBEN. — 495.

The PRESIDENT. — Would there be about eight persons to each taker, on an average, or about how many? You don't mean only 500 people?

Mr. STEBEN. — No; 495 families.

The PRESIDENT. — Would eight be a fair average for the number of people in a family?

Mr. HAWES. — It is in Canada, you know; you had better call it ten, I guess. (Laughter.)

Mr. STEBEN. — No; that would be rather too high; six would be about the average.

The PRESIDENT. — If it was eight it would be about 220 gallons a head.

Mr. HAWES. — Take the whole population, and it would be about 100 gallons. That is the way we get at it usually in the States, figure it *per capita*. We have 100,000 inhabitants in Fall River, and we use 60 or 80 gallons *per capita*; while in the big city of New London (laughter) they use about 100 gallons, the same as you do.

The PRESIDENT. — I will now call upon Mr. Noyes, of Newton.

AN EXPERIENCE IN EXCAVATING IN QUICKSAND.

BY

ALBERT F. NOYES. Read March 12, 1890.

Mr. NOYES. — Mr. President, some years ago I had occasion to make an excavation in material known as quicksand, some 15 feet deep, near buildings. If the excavations were made in the ordinary way, a settlement of the foundations would be likely to occur, so I adopted the following method, which in my case proved successful; and I see no reason why, under similar conditions, and in a great many cases, it could not be used to advantage. The excavation, as I have said, was about 15 feet deep, about 60 feet in length, and 8 feet wide. Usually below these veins of quicksand there are veins of a coarse material which form ready conductors for the water, and the vertical distance through the quicksand is usually less than the horizontal distance; the ground water has the least resistance in the vertical direction, and tends to soften and take up the quicksand with it. If the water is drawn out, or the water level lowered below the bottom of the trench, this fine material becomes compact, very much like

clay, and excavations can be easily made with perfect safety, and the use of a light sheeting. In the case I refer to I used fourteen 1½-inch pipes, which were driven equidistant about the excavation to be made with the ordinary perforated well point, having attached outside a fine-mesh brass screen. They were driven into a stratum of coarse material from 35 to 50 feet below the surface of the ground. The pipes were ganged together, and attached to a common plunger pump, and the water was drawn down. I might state that the normal level of the ground water was within some 3 or 4 feet of the surface of the ground, so we had to draw the ground water down some 10 or 11 feet. We found by test tubes outside of the gang that we could readily hold the water to a level, which insured the excavations being made without any difficulty whatever; in fact, the banks were dry, and the lower portion of the excavation was very firm. In this case the well points, after we used them, were sold to other parties at nearly the first cost. The pipes, which were taken from the stock at the pipe yard, were returned and used over again, so that there was little loss in that way; and the whole cost of driving the pipe was about $18, so that the expense of that method was really less than sinking a well outside of the excavation in the usual manner.

Mr. ALLIS. — As Mr. Noyes has had some experience with a certain locality I am acquainted with in Malden, where we have got a lot of pipes driven, and as I expect to do something similar to what he has been telling us about, I would like to ask him whether he thinks if I was to drive six or seven or eight pipes I would be able to do as well as he did, and get rid of the water in that way?

Mr. NOYES. — This gang of pipes surrounded the excavation.

Mr. ALLIS. — Seven or eight of them?

Mr. NOYES. — There were fourteen of them, — 1½-inch pipes. In this case the stratum was not as coarse as I would liked to have had it, so I drove these pipes with well points; that is, perforated points with the brass strainers. In your case, I would say that in our experiments at Malden we held the water down 18 to 22 feet in the immediate vicinity of the well. That is, should you adopt the same method, under the conditions that existed in the Malden test, you could hold the water from 16 to 20 feet inside of such a gang of wells, below the surface. In the Malden case the level of the ground water before pumping rose to the surface. Of course you can't ordinarily get a vacuum above 22 or 23 inches. If you have tubes enough you can hold the water down somewhere from 16 to 22, according to the coarseness of the feeding material or medium.

Mr. ALLIS. — May I ask what kind of a pump you used, — how much of a pump?

Mr. NOYES. — It was a Blake Tank Pump. We got from 90,000 to 100,000 gallons in 24 hours, and we pumped continually during the work. I forget now just the size of it.

Mr. ALLIS. — We would have to have quite a pump to handle the water there, — more of a pump than you used.

Mr. NOYES. — It would depend upon how much of an excavation you wanted to make. For instance, in your case, where we had, I think, thirteen or fourteen 2½-inch tubes, we were pumping between 800,000 and 1,000,000 gallons in 24 hours; but during the pumping we held the water down in the test tubes that lay within the area of the ganged wells, I think, about 20 feet. We got a 23-inch vacuum.

Mr. ALLIS. — I see what you are driving at; I get the idea, but what I wanted

to find out was, if I go to work and do that, how large a pump I have got to put on there. As I understand you now, I will have to get quite a large pump, because we are doing that very thing now, — we are drawing the water down 20 feet, and we have a million and a half of gallons pump. I want to know with how small a pump I can handle that sort of thing.

Mr. NOYES. — I think it depends upon how large an area you want to make your excavation in.

Mr. ALLIS. — It is in the sand, about 60 feet away from the pump station, where our wells are.

Mr. NOYES. — How long an excavation?

Mr. ALLIS. — I want to make one 20 or 30 feet in diameter and 10 feet deep, for an open well. That ground is pretty bad quicksand, you know.

Mr. NOYES. — I should think under these conditions, with all the conditions as I have seen them at your place, you would want a pump which would pump well on to a million gallons.

Mr. ALLIS. — That is what I wanted to get at; I am much obliged.

Mr. WINSLOW. — Wouldn't it be better for Mr. Allis to put in some sheet plank around his excavation, make a rib, something of that kind, suppose it is a round well, and use a centrifugal pump?

Mr. ALLIS. — That is a plan I had thought of in my own mind, but hearing this from Mr. Noyes, I thought I would like to get some information in regard to it. I think, myself, something of that kind would be better for me.

Mr. NOYES. — The main value of the method I suggest is where you have buildings near your excavation, and you don't want to run the risk of drawing the material from under their foundations. In this way there is practically no running of the material, that is, the sand will not run, if you have held the ground water down to that point, because the vein of sand is ordinarily fed from that vein of coarser material beneath.

The PRESIDENT. — Mr. Allis speaks of pumping now from a number of wells. I would like to ask him how large an area these wells cover. If I understand correctly, Mr. Noyes refers to pumping the water from a comparatively small area during an excavation; while in your case I think your wells cover somewhat of a large area. In a smaller area you would get a smaller quantity of water, and by having the driven wells around the well, you would not draw the sand into the well with the water, as you would with the centrifugal pump.

Mr. ALLIS. — I would say that we have 51 wells arranged in rows and gangs, so that they occupy a space, I think, about 100 feet in length by 60 feet in width — perhaps a little less in width, I am not quite sure about that. My proposition is to put down a well some 50 feet beyond the gangs, and 60 feet from my house. I have a very bad quicksand there, and I don't want the foundations to give way. I don't know but I could put in some small pipes and a small pump, but perhaps if I should sheath it and hold it, and put on a centrifugal pump, that might be the cheapest. Or I might put my big pump on there; perhaps I can do that.

Mr. CHACE. — I have prepared a short sketch of an experience with artesian wells. There was an account of this in the last report of the Water Commissioners of Taunton, which I think you have all received. It contains a map, and if any of you have not received a copy, I should be glad to send you one.

ARTESIAN WELL EXPERIMENT AT TAUNTON.

BY

GEORGE F. CHACE. Read March 12, 1890.

To give a full history of this well and the reasons for the experiment would consume an hour. A few of the most interesting features are here briefly stated.

A contract was made with the Pierce Artesian and Oil Well Supply Co., of New York City, to drill an 8-inch hole for a certain price per foot, the water department to furnish steam for their engine. The hole was to be not less than 50 feet, nor more than 1,000 feet, at the stipulated rate. Other details of the contract it is not necessary to mention.

Drilling was commenced at noon, April 5, 1889. The first 50 feet consisted of sand and fine gravel with more or less clay; the last 10 feet being mostly clay. This was followed by 2 feet of water-bearing sand. No attempt was made to determine the quality or quantity of the water at this point. Several driven wells had already been put down into a similar layer, at approximately the same depth, and the quantity of water to be obtained was already known to be too small for our purpose. For the next 33 feet the drill went through the hardest kind of blue clay.

At a depth of 85 feet rock was reached. This was a hard sandstone, closely resembling fine granite.

An 8-inch wrought-iron pipe with a shoe upon the lower end, and in sections averaging 10 feet in length, and fastened together by thread joints, was driven firmly down into the rock. The hammer was the trunk of a white oak-tree, about 22 inches in diameter at the larger end, and about 20 feet long.

The whole depth drilled was 975 feet. The rock consisted of alternating layers of sandstone, blue clay slate, coal slate, and quartzose conglomerate. There were eight layers of sandstone, seven of coal slate, seven of blue slate, two of quartzose conglomerate, and two that were a mixture of all. These layers varied in thickness, that is, in the direction of the drill, from 5 to 95 feet. As a core drill was not used, the thickness of the strata, of course, cannot be given with absolute scientific accuracy, but by examining every day the drillings which were brought up by the sand-pump, and by frequent measurings of the depth of the bore, it was possible to make a fair approximation to actual facts.

A diary was kept during the progress of the work, and specimens of the drillings preserved, representing every five or ten feet of the whole distance through which the drill passed.

One hundred and forty bottles of these samples are now labelled and put away in the office of the water commissioners. A duplicate set has been furnished the United States Geological Survey.

The sediment in the sand-pump was commonly of the consistency of sand. Sometimes rock chips as large as walnuts were drawn up.

During the driving of the pipe, work was continued for the ordinary ten hours a day. April 13, eight days from the start, rock was reached, and thereafter drilling was performed during the whole twenty-four hours.

At 7.30 P.M., Sunday, May 5, the surface of the water in the well was 16½ feet below the surface of the ground. The depth of the well at this time was 270 feet.

At a depth of 305 to 317 feet a stratum of quartzose conglomerate was encountered. This for the most part was very hard, and dulled the bits so rapidly that very slow progress was made. In the midst of this stratum seemed to be a crevice of sand, which gave a great deal of trouble by falling into the well.

May 19, when the depth was 323 feet, the water was within 15 feet of the top, — a gain of one foot and four inches over the previous week.

From July 19 to August 2 a great deal of difficulty was encountered and very little progress was made. The bit descended into a crevice which had a tendency to make the hole crooked, and thus jam the tools and stop them. The bit was temporarily replaced by a reamer.

July 25, the whole string of tools was caught in the crevice and work stopped. Fishing tools were shipped from New York, and finally, on August 1, the lost tools were recovered and reaming resumed. In a day or two the hole was straightened and the drilling again advanced.

August 9, at 10 A.M., the water was 11 feet and 6 inches from the top, and the depth of the well about 562 feet.

From October 31 to November 12 the use of a reamer was necessary much of the time, on account of a troublesome crevice. In fact, on the latter date the reamer in use was broken, and work was stopped, until a new one was obtained.

December 1, the level of the water was 11½ feet below the surface of the ground. It never rose higher than this without pumping. The depth of the well at this time was 950 feet, and the drill was in a coal slate.

December 5, drilling ceased and a final measurement was made of the depth of the well. This proved to be 975 feet. The last 25 feet had been through hard sandstone.

At this period neither party was anxious to pursue the experiment further. A pumping test was at once made, to determine the amount of water which the well could be depended upon to furnish. A 4-inch wrought-iron pipe, in lengths of 20 feet, with thread joints, the pipe ends coming together flush, was sunk to a depth of 420 feet, and a 3¾-inch working barrel placed at a depth of 400 feet.

The piston-rod of the pump was made of 1¼-inch wrought-iron pipe. Pumping began at 11 A.M., Thursday, December 5, and continued night and day until Thursday morning, December 12.

The result of the test, and of the whole experiment, can be best summed up in the following quotation from the last annual report of the water commissioners :—

"During the forenoon of the first day's trial, the pumping was forced to a speed, for a minute, which caused it to throw water at the rate of about 200,000 gallons in 24 hours. The Board were not satisfied that this test made by the contractor was conclusive. Accordingly, from time to time, during the progress of the pumping, various tests were made. In brief, the result of these tests, based upon the size of the pump, the length of stroke, the rate of speed, and the observed time and rate required to exhaust the water, convinced the commissioners that the capacity of the well would not exceed 75,000 gallons a day, and might, perhaps, be reckoned with safety at about 70,000 gallons in 24 hours. To obtain even this quantity would require a deep well pump.

"Although the Board had hoped that sufficient water might be produced from this well alone, to justify the expectation of a satisfactory addition to our supply by means of two or three more, this hope has not been realized.

"The well may, however, be, after all, of some use. If the mineral analysis proves to be what they anticipate, and means of pumping can be devised not too expensive, the commissioners may conclude that, by pumping directly into the pump well a colorless artesian water of good quality, which will amount in quantity to nearly 8 or 10 per cent. of the daily consumption, the water from the filter basin may, during the hot weather, be rendered more palatable."

Mr. HAWES.— What was the quality of the water?

Mr. CHACE.— The quality is good.

Mr. HAWES.— I am rather glad to hear this paper, because the first reports we got down at Fall River were that they had struck water in Taunton in one well at the rate of five million gallons a day, and they were going to put in twenty of them, and we were going to sell out our water works in Fall River, and get a supply from Taunton (laughter), and they were going to take a contract to fill the Atlantic Ocean. (Laughter.) I have never been able to get at the real facts before, and I am glad to find them out now.

Mr. ALLIS.— May I ask the gentleman what the cost of the work was?

Mr. CHACE.— It cost $7 a foot.

Mr. ALLIS.— The total cost?

Mr. CHACE.— The total cost was about $8,000.

Mr. HOLDEN.— I would suggest that perhaps you might get more water by blasting that well; do you think of doing so?

Mr. CHACE.— That matter was thoroughly considered. Before the experiment ended I began to hedge. I anticipated the thing might be a failure, and I sent all over the country, to every place where I knew there was an artesian well, circulars asking about the depth of the well, how many gallons it yielded, what kind of rock strata was there, who did the drilling, whether the water was of good quality, and if they had shot the well, and if so what the result of it was. With regard to the effect of shooting a well, I found that about one time in three the explosion increased the water, but sometimes it diminished the supply. The well-drillers themselves who worked there were unwilling to take the risk of doing it, because there was so much material they thought might be likely to cave in and spoil the whole thing.

Mr. HOLDEN.— I have blasted several wells of that kind, and all of them but one resulted in giving more water; I never knew of a case of its being less. I blasted one on the Hudson river, a well about 1,000 feet deep, for a paper-mill, where they wanted to get a large supply of pure water for making note-paper. The supply was very small indeed. I put in three charges of nitro-glycerine, 25 pounds to a charge, and it was successful, as I think they have since had all the water they needed. This depends a good deal, however, upon whether there are any water-bearing veins anywhere in the vicinity. If there are, a heavy explosive will sometimes open the veins so as to get a great deal more water. But I don't understand how the effect would be to close anything up so as not to get as much, unless the well caved in. It might do that, if it was in very soft material. But, ordinarily, it makes a large chamber wherever the explosive lies.

MR. CHACE.— I remember an account of a well where they had a fair amount

of water before the explosion took place, and afterwards they got nothing; and we had some caving material where we were, and it looked as if it was risky to undertake it.

Mr. HOLDEN. — At the Lowell Hosiery Mills, in Lowell, they blasted a well some four or five years ago, and increased the flow very considerably by that.

Mr. HAWES. — There was a well driven in Fall River some six or seven hundred feet, and in going down they went through a very nice streak of plumbago; and when they got clear down, they blasted the well. Some five or six hundred citizens had gone down to see the blast, and when the explosion came it sent a column of about as inky-looking stuff as you would want to see 300 feet into the air. The five or six hundred citizens weren't quick enough in getting out of the way, and they got a pretty good dose. (Laughter.) We heard a great deal of what that well was going to do. They were going to demolish this monopoly of the water works (laughter); but we have never heard from it since. I don't know what they use the water for. It certainly isn't good enough for drinking, it is rather bad for engine boilers, and it is a little dark for washing, and what they use it for I don't know. (Laughter.) There have been four or five of these wells drilled in Fall River, but I don't know that any one of them has been put to any practical use. There is one at the brewery, — any water, you know, is good enough for beer (laughter), — and the man who drilled it didn't care how much money he spent, so every hundred feet he would send a sample of it down to Boston and have it analyzed. The last time I saw him he hadn't got it good enough, but he had got about as far down as he was going with it. He uses the water for washing his bottles, but not for making his beer. He continues to use our pond water to make his beer with. I haven't heard of a well yet which can be put alongside of any good pond supply. If anybody knows of any such, let us hear from him about it. (Laughter.)

Mr. HOLDEN. — I have heard a good deal about an artesian well at Lawrence, at Stanley's brewery; perhaps Mr. Salisbury can tell us about that.

Mr. SALISBURY. — I think you must be mistaken; I never have heard of any. The only well they have there spouts lager beer. (Laughter.)

Mr. HYDE. — Before we adjourn I might speak of a little experience I had a short time ago in painting and repacking some hydrants and flushing my mains. I had occasion to open a hydrant which is used for a blow-off. It was situated near a fence where the sun hardly struck it all day, so the casting was undoubtedly full of frost, and perhaps there was some air in the hydrant. The man who had the wrench opened the hydrant about three turns, and as soon as he did that, the hydrant blew out, and exploded with a report about as loud as a gun. The hydrant was blown all to pieces from the street level, so we picked it up in small pieces as large as your two hands. I found in examining the casting that there was a flaw on one side of the post where the iron was about three-eighths of an inch thick, for the length of about a foot, — a cold schut in the casting. But I presume the principal cause was, perhaps, some air and the frost in the iron, because the hydrant had been used for that purpose for two years. That may be a little experience some of the other members have not had. I had never had anything of the kind before.

Mr. HOLDEN. — What kind of a hydrant was it?

Mr. HYDE. — It was the Carr supplementary hydrant.